UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION No. 631

WASHINGTON, D. C. September 1947

# THE FLIES THAT CAUSE MYIASIS IN MAN

BY

MAURICE T. JAMES

Entomologist

Division of Insect Indentification
Bureau of Entomology and Plant Quarantine
Agricultural Research Administration



UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1947

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 35 cents

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION NO. 631

Washington, D. C. September 1947

# THE FLIES THAT CAUSE MYIASIS IN MAN

By Maurice T. James

*Entomologist, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration*[1]

## CONTENTS



[1] Acknowledgment is made to many persons for help and suggestions, but particularly to Alan Stone and Charles T. Greene, of the Division of Insect Identification, for critical reading of certain parts of the manuscript, and to the Division of Insects Affecting Man and Animals for some of the illustrations used in this work. The original drawings and diagrams were made by Arthur Cushman, of the Division of Insect Identification.

CONTENTS—Continued



## INTRODUCTION

From the standpoint of medical entomology by far the most important insects are the Diptera or two-winged flies. Many of these, such as the haematophagous mosquitoes, the blackflies, the horseflies and deer flies, and certain muscoids, are bloodsuckers, and in this role may act as vectors of pathogenic organisms, either mechanically or through cyclic transmission. A great many other species breed in carrion, excrement, or other types of filth, from which they may carry pathogens to our food or drinking water, or directly to the human body. Still others, almost exclusively nonbloodsuckers in the adult stage, may attack the human body as larvae, thus producing the pathogenic condition known as myiasis.

The term "my[i]asis," proposed by Hope in 1840 (*60, p. 258*), is now in general use to indicate the condition resulting from the invasion of tissues or organs of man or animals by dipterous larvae. Somewhat earlier, Kirby and Spence (*70, vol. 1, ed. 3, p. 100*) had proposed the name "scolechiasis" for such invasions by insect larvae in general. Hope, however, proposed to limit that term to use in connection with lepidopterous larvae, and suggested the new terms "my[i]asis" and "cantharisis," the latter to refer to pathological conditions caused by the larvae of Coleoptera. Patton (*100, 102*) extended the use of the term myiasis to include all stages of Diptera on the ground that eggs, pupae, and even adults may occasionally be found in the human body. Since, however, it is the larva that is the active stage in relation to myiasis, this extension of the term is unnecessary and may be confusing. Attacks of bloodsucking maggots (of which only one affects man), while not in the true sense myiasis, are considered related phenomena and are therefore included briefly in this work, but no consideration is given to bloodsucking adults.

Much has been published on the subject of myiasis, but the literature is scattered. The larger works either treat of it in general from a restricted geographical standpoint or deal with certain important species or groups of related species on a broader scale. There are several general reviews, aside from those in textbooks, but they are brief. Much of the literature needs critical reexamination, since misinterpretations of the data and misidentifications of the insects involved have been common.

The need for a general guide to the subject became evident when, in the progress of World War II, information was sought which could be answered, if at all, only by a search through sources published in many countries and in several languages. Needs arising from war have had a large share in shaping the general plans of this work, although much consideration has also been given to the needs of postwar reconstruction and of civilian life in a peacetime world.

The aim of this work, then, is to summarize pertinent biological and pathogenic information concerning the myiasis-producing flies of the world insofar as they affect the human host, and to present guides for their identification. In general, species reported as attacking only the lower mammals have been excluded, except in cases where man may be considered a possible host. Much of the information has necessarily been gleaned from the literature. Whenever possible an attempt has been made to evaluate the statements, but, for lack of complete information in the reports, this has often been impossible. For this reason some species undoubtedly have been incorrectly included in this list whereas others of importance may have been omitted.

Statements regarding pathological and clinical aspects are especially subject to inaccuracies, and many of them must be accepted provisionally. Very little experimental work has been done on myiasis, and for most of the information we must depend on case histories, many of which were reported by physicians having little or no entomological training. One source of error lies in the possibility of misinterpreting clinical data. For example, in some cases diagnosed as gastrointestinal myiasis actually the larvae either made their way into chamber vessels which one would ordinarily consider closed sufficiently tight to exclude them, or else they were passed with the urine or dropped from infested sores in the rectal or vaginal region. Still another source of error lies in misidentification, particularly when no adults have been obtained. These errors may be published and perpetuated by repetition, and, unfortunately, in most cases there is no way of distinguishing them from correct reports.

Some further statements regarding the scope and limitations of this work are desirable. In the first place, no pretense of deciding any taxonomic issues is made, nor is any degree of completeness claimed in dealing with taxonomic groups. Attempts are made to deal only with the known or strongly suspected producers of myiasis in man. Since it is impossible to foresee just what should be included in this category, citations to keys and other references useful in the study of the biology and taxonomy of related species have been included. Such citations, however, have been held to the minimum.

Most of the keys used here have been adapted from published works, although some of them are original. Those that have been borrowed or adapted have been checked against determined material in the collections of the United States National Museum. For this purpose

adult specimens of almost all the species treated here have been available, but the situation in regard to the larvae has not been so fortunate. For brevity in treatment, only those characters considered to be diagnostic are discussed in the descriptions of both larvae and adults.

In most species, only the mature larva is described, partly because of the limitations of the published records and partly because that stage is the most significant, the earlier stages in many flies being of short duration. When, however, there are sufficiently well-marked characters for the earlier stages, or when they are of more importance, as in *Oestrus* and *Gasterophilus*, these are given due consideration.

Some may question the value of detailed citation of political units under the heading of geographical distribution, where, it may be felt, general statements might suffice. It is the author's experience, however, that this detailed information is often requested, and is much harder to trace in the literature than is almost any other body of facts relating to the problem at hand.

The total known geographical distribution for each species is given, not merely the records for myiasis. The lists have been prepared from published records, those which are clearly or probably erroneous being omitted, and from specimens present in the collection of the United States National Museum or determined by the author from other sources. Geographical names have been standardized according to those used by the National Geographic Society, Washington, D. C., in the World Map published December 1943 (international boundaries as of September 1, 1939), except that the boundaries of Austria and Czechoslovakia prior to the German invasion and the boundaries of Ethiopia prior to the Italian invasion are accepted. When greater detail was necessary, other maps of the Society for the same general period were consulted. For convenience, political units were grouped according to the zoogeographical regions of Wallace rather than according to continents. When one political unit falls within two zoogeographical regions, it is considered under the region that contains the larger part; for example, China is considered Palaearctic, India Oriental, and Mexico Neotropical.

Some of the most important general works on myiasis are those by Dove (*34*)[2] for the United States, Mazza and coworkers (*87*) for Argentina, Mumford (*91*) for England, Lampa (*79*) for Sweden, Portchinsky (*115*, *116*, *117*, *118*,) for Russia, Onorato (*96*) for Tripolitania, Roubaud (*126*) for Africa, Lewis (*83*) for Kenya, and Porter (*119*) and Bedford (*13*) for South Africa. Patton (*100*, *101*) deals with the subject of myiasis in general, but his work, particularly the second paper, is of especial value in relation to the Indian fauna.

The taxonomic literature covering the groups treated in this work is voluminous. Important pertinent citations are given in the proper places in the text, but a few general works and series of works deserve mention. C. H. Curran's "The Families and Genera of North American Diptera" (New York, 1934) gives keys to the genera of Diptera occurring in North America, with numerous illustrations and other valuable material. C. H. T. Townsend's "Manual of Myiology," in 12 parts, (Sao Paulo, Brazil, 1934–42), is indispensable to the study of the muscoid flies; it deals, however, only with genera (used in a greatly restricted sense) and higher categories. "Die Fliegen der

[2] Italic numbers in parentheses refer to Literature Cited, p. 164.

Palaearktischen Region," edited by Erwin Lindner (Stuttgart), gives keys and descriptions, with numerous illustrations, of all the Palaearctic Diptera; thus far the families Sylvicolidae (as Phryneidae), Stratiomyidae, Therevidae, Syrphidae, Tylidae, Ephydridae, and Drosophilidae, as well as some that contain no myiasis-producing species, have been published. In the "Fauna of British India, Diptera" (London, 1920–40), the parts pertinent to this work that have been published are volume II (including the Stratiomyidae and Therevidae), volume III (including the Syrphidae and Oestridae in a broad sense), and volume VI (comprising the Calliphoridae, including the Sarcophagidae).

## TYPES OF MYIASIS

Two general plans have been used for the classification of myiasis. The one, that of Patton, is based on the biological requirements and responses of the fly in its various stages of development; the other, that of Bishopp, is concerned with the part of the body affected. Each classification has its particular use; Patton's is the more satisfactory from the standpoint of the student, whereas Bishopp's is of more use to the practicing physician and the practical medical entomologist.

### PATTON'S CLASSIFICATION

Patton (*100*, *102*) divides the myiasis-producing Diptera into three groups. The first group, the specific myiasis-producing Diptera (table 1), includes those species "whose larvae are found only in living tissues, the flies selecting a number of tissues or organs, or one particular organ, depending on the species, in which or near which to lay their eggs or deposit their larvae." This group, therefore, comprises a relatively small number of species to which the parasitic habit has become obligatory. It also comprises the most serious myiasis producers from a pathogenic standpoint, since its larvae do not utilize carrion or other nonliving material as an alternative breeding medium. They may attack wounds, skin, or the external body openings, but never the digestive tract. Members of this group are scarce as adults, in comparison with carrion-breeding and other species that are not strictly parasitic; and for this reason the true etiological agent and the nature of its parasitism has, in several instances, remained obscure until comparatively recent times.

The second, or semispecific, myiasis-producing group (table 2) includes "those flies which, though normally breeding in the bodies of dead animals, and even in vegetable matter, will occasionally lay their eggs, or deposit their larvae in the diseased tissues of man or animals." Oviposition or larviposition is stimulated by foul or fetid odors; the female fly will not deposit eggs or larvae on unbroken skin or on fresh, clean wounds. A fetid discharge from a body opening, however, or, in the case of sheep or other wooly animals, soiled wool may be a sufficient attractant to the fly. The developing larvae may confine their activities to necrotic tissue; on the other hand, they may invade the deeper, sound tissues. Some members of this group are of little importance from the standpoint of human and animal myiasis; some, however, may be dangerous.

The third, or accidental, myiasis-producing group (table 3) consists of an assemblage of more or less unrelated Diptera, the larvae of which occasionally find their way into the human body, usually the gastrointestinal tract. For the most part this group contains species which breed in various substances, including some used by man as food, and which occasionally are taken with the food into the human digestive tract, where they survive with varied success. Certain members of this group may even enter the urinary passages and bladder. More rarely, others attack wounds or the cavities of the head, but such invasions seem purely accidental and are usually unsuccessful. Some members of this group are of moderate importance as myiasis producers.

The division betwee nthe first and the other two groups is clear-cut, the only question being the specificity of the fly larva on living human or other mammalian tissue. The second and third groups cannot be separated so definitely. A real question might arise, for example, as to the position of the species of *Musca*, *Muscina*, *Fannia*, *Megaselia*, and certain *Sarcophaga*. These species might be considered intermediate between the true semispecific and the purely accidental myiasis producers.

TABLE 1.—*Specific myiasis-producing Diptera*

| Family and species | Cutaneous or subcutaneous | | | | Cavity | | |
|---|---|---|---|---|---|---|---|
| | Traumatic | Creeping | Furuncular | Nose, mouth, and sinuses | Eyes | Ears | Anus, vagina, etc. |
| SARCOPHAGIDAE | | | | | | | |
| *Wohlfahrtia magnifica* | x | | | x | x | x | x |
| *Wohlfahrtia vigil* | | | x | | | | |
| *Wohlfahrtia opaca* | | | x | | | | |
| CALLIPHORIDAE | | | | | | | |
| *Calliiropa americana* | x | | x | x | x | x | x |
| *Chrysomya bezziana* | x | | | x | x | x | x |
| *Auchmeromyia luteola* [1] | | | | | | | |
| *Cordylobia anthropophaga* | | | x | | | | |
| *Stasiria rodhaini* | | | x | | | | |
| GASTEROPHILIDAE | | | | | | | |
| *Gasterophilus intestinalis* [2] | | x | | | x | | |
| *Gasterophilus haemorrhoidalis* | | x | | | | | |
| *Gasterophilus nasalis* | | ? | | | | | |
| HYPODERMATIDAE | | | | | | | |
| *Hypoderma diana* | | x | x | | x | | |
| *Hypoderma bovis* | | x | x | | x | | |
| *Hypoderma lineatum* | | x | x | | x | | |
| CUTEREBRIDAE | | | | | | | |
| *Cuterebra sp* | | | | x | | | |
| *Cuterebra buccata* | | | x | | | | |
| *Dermatobia hominis* | | | x | | | | |
| *Cephenemyia sp* | | | | ? | | | |
| OESTRIDAE | | | | | | | |
| *Oestrus ovis* | | | | x | x | x | |
| *Rhinoestrus purpureus* | | | | | x | | |

[1] Bloodsucking maggot.

[2] Undetermined species of *Gasterophilus* are also recorded in enteric myiasis.

TABLE 2.—*Semispecific myiasis-producing Diptera*

| Family and species | Traumatic | Cavity | | | | | Enteric |
|---|---|---|---|---|---|---|---|
| | | Unspecified | Nose, mouth, and sinuses | Eyes | Ears | Anus, vagina, etc. | |
| **SARCOPHAGIDAE** | | | | | | | |
| *Wohlfahrtia nuba* | x | | | | | | |
| *Titanogrypha alata* | x | x | x | | | | |
| *Sarcophaga haemorrhoidalis* | x | x | | | | x | x |
| *Sarcophaga placida* | x | | | | x | | |
| *Sarcophaga plinthopyga* | | x | | | | | |
| *Sarcophaga lambens* | x | | | | x | | |
| *Sarcophaga chrysostoma* | ? | | | | | | |
| *Sarcophaga misera* and related species | x | | x | | | | ? |
| *Sarcophaga crassipalpis* | x | | | | | | |
| *Sarcophaga barbata* | x | | | | | | |
| *Sarcophaga bullata* | x | | | | | | x |
| *Sarcophaga cooleyi* | | | | | x | | |
| *Sarcophaga striata* | x | | | | | | ? |
| *Sarcophaga fertoni* | x | | | | | | |
| *Sarcophaga ruficornis* | x | | | | | | ? |
| *Sarcophaga peregrina* | x | | | | | | ? |
| *Sarcophaga nodosa* | | | | | x | | |
| *Sarcophaga froggatti* | ? | | | | | | |
| *Sarcophaga carnaria* | x | x | x | x | x | x | ? |
| *Sarcophaga albiceps* | x | | | | | | |
| *Sarcophaga beckeri* | x | | | | | | ? |
| **CALLIPHORIDAE** | | | | | | | |
| *Callitroga macellaria* | x | | | | | | |
| *Microcalliphora varipes* | ? | | | | | | |
| *Chrysomya marginalis* | x | | | | | | |
| *Chrysomya albiceps* | ? | | | | | | |
| *Chrysomya chloropyga* | x | | | | | | x |
| *Chrysomya rufifacies* | ? | | | | | | |
| *Chrysomya putoria* | ? | | ? | | | | |
| *Chrysomya megacephala* | x | x | x | | | | ? |
| *Chrysomya micropogon* | ? | | | | | | |
| *Phormia regina* | x | | | | | | ? |
| *Protophormia terrae-novae* | ? | | | | | | |
| *Lucilia caesar* | x | | | | x | | ? |
| *Lucilia illustris* | x | | | | | | |
| *Phaenicia cuprina* | x | | | | | | |
| *Phaenicia sericata* | x | | x | | x | | ? |
| *Cynomyopsis cadaverina* | x | | | | | | |
| *Adichosiopa quadrimaculata* [1] | ? | | | | | | |
| *Neopollenia stygia* [1] | ? | | | | | | |
| *Neopollenia laemica* [1] | ? | | | | | | |
| *Neopollenia australis* [1] | ? | | | | | | |
| *Neopollenia rufipes* [1] | ? | | | | | | |
| *Neopollenia fatiax* [1] | ? | | | | | | |
| *Anastellorhina augur* [1] | ? | | | | | | |
| *Anastellorhina nocira* [1] | ? | | | | | | |
| *Calliphora vicina* | x | | x | | x | | x |
| *Calliphora croceipalpis* | x | | | | | | ? |
| *Calliphora vomitoria* | x | x | | | | | x |
| *Synthesiomyia nudiseta* | x | | | | | | |
| **MUSCIDAE** | | | | | | | |
| *Peronia rostrata* [1] | ? | | | | | | |
| **PHORIDAE** | | | | | | | |
| *Megaselia scalaris* | x | | | x | | | x |
| *Megaselia rufipes* | x | | | | | | ? |

[1] Australian sheep maggots.

TABLE 3.—*Accidental myiasis-producing Diptera*

| Family and species | Traumatic | Cavity | | Bladder, urinary passages | Enteric |
|---|---|---|---|---|---|
| | | Nose, mouth, etc. | Ears | | |
| SARCOPHAGIDAE | | | | | |
| *Sarcophaga l'herminieri* | | | | | ? |
| *Sarcophaga hirtipes* | | | | | ? |
| CALLIPHORIDAE | | | | | |
| *Pollenia rudis* | | | | | ? |
| MUSCIDAE | | | | | |
| *Anthomyia pluvialis* | | | ? | | ? |
| *Paregle radicum* | | | | | x |
| *Hylemya spp.* | | | | | ? |
| *Fannia scalaris* | | | x | x | x |
| *Fannia manicata* | | | | | x |
| *Fannia inciurata* | | | x | | x |
| *Fannia canicularis* | ? | | x | x | x |
| *Fannia fusconotata* | | | | ? | |
| *Hydrotaea meteorica* | | | x | | x |
| *Stomoxys calcitrans* | x | | | | x |
| *Muscina stabulans* | ? | | | | x |
| *Muscina assimilis* | ? | | | | |
| *Musca crassirostris* | | | | | x |
| *Musca domestica* [1] | x | x | x | x | x |
| TIPULIDAE | | | | | |
| Species undetermined | | | | | x |
| PSYCHODIDAE | | | | | |
| *Psychoda albipennis* | | | | x | |
| *Psychoda alternata* | | | | | x |
| SYLVICOLIDAE | | | | | |
| *Sylvicola fenestralis* | | | | | x |
| STRATIOMYIDAE | | | | | |
| *Hermetia illucens* | | | | | x |
| THEREVIDAE | | | | | |
| *Thereva (nobilitata?)* | | | | | x |
| SYRPHIDAE | | | | | |
| *Syrphus* spp. | | | x | | ? |
| *Tubifera tenax* | | | | | x |
| *Tubifera dimidiata* | | | | | x |
| *Tubifera arbustorum* | | | | | x |
| *Helophilus pendulus* | | | | ? | ? |
| DROSOPHILIDAE | | | | | |
| *Drosophila melanogaster* | | | | | ? |
| *Drosophila funebris* | | | | | x |
| EPHYDRIDAE | | | | | |
| *Teichomyza fusca* | | | | x | ? |
| TYLIDAE | | | | | |
| *Trepidaria cibaria* | | | | | ? |
| PIOPHILIDAE | | | | | |
| *Piophila casei* | | x | | | x |
| SEPSIDAE | | | | | |
| *Sepsis* sp. | | | | | x |
| LARVAEVORIDAE | | | | | |
| *Mintho algira* | x | | | | |

[1] Also reported in ocular myiasis.

## BISHOPP'S CLASSIFICATION (MODIFIED)

Bishopp and others who have followed him have devised a classification of myiasis based on the part of the body affected. Bishopp's five original categories were tissue-destroying forms, subdermal mi-

gratory forms, larvae infesting the intestinal and urogenital tracts, forms infesting the head passages, and bloodsucking forms (Bishopp, Laake, Brundrett, and Wells, *17*). A similar but somewhat more extended classification has been used by Townsend and others. Such a classification, as indicated by Patton, has the objectionable feature that many species of flies will fall into two or more categories, but it will better serve the needs of the physician who must make a diagnosis and prescribe treatment.

The classification used in this work is as follows: Traumatic (wound) myiasis; myiasis of the nose, mouth, and accessory sinuses; aural myiasis; ocular myiasis, internal and external; myiasis of the anal region and vagina; myiasis of the bladder and urinary passages; furuncular, dermal, or subdermal myiasis; creeping, dermal, or subdermal myiasis; and enteric (gastrointestinal, gastric, or intestinal) myiasis. In addition to the forms of true myiasis, attacks by bloodsucking larvae are also considered as a related phenomenon.

## TRAUMATIC (WOUND) MYIASIS

Infestation of wounds in man and animals by dipterous larvae is common. Often the infestation is benign, as when festered, malodorous wounds are attacked by secondary invaders which confine their activity to the diseased tissue, but when primary parasites or secondary invaders that burrow below the superficial necrotic tissues are present, results can be and often are serious. The literature abounds in case histories and general accounts; the following will serve as examples.

Galli-Valerio (*43*) cites a case of myiasis so serious that it resulted in the amputation of a hand. A farmer in Valais, Switzerland, suffering from actinomycosis complicating a wound on the left hand, had been given a treatment which had reduced the ailment to a small nodule. After returning to field work, the patient noticed that the nodule had become ulcerated, and one day he squeezed a large number of maggots out of the wound. In spite of Galli-Valerio's advice, the condition was allowed to progress to the point that, when a surgeon was finally consulted, the hand had to be amputated. Maggots were reared and found to be *Lucilia caesar*.

Onorato (*96*) cites a case in which a young man of 18, injured by a blow received from the backfire of a gun, had lain for several days in a comatose state and was finally brought to the hospital in a critical condition. Maggots of *Phaenicia sericata* had invaded the scalp wound produced by the injury and had formed numerous ulcers on the thorax; in addition, they had invaded the oral and nasal cavities, exposing the maxillary and palatine bones in several places, eating away the floor of the nasal cavity to the bone, and perforating the tympanum of the right ear. In spite of the severe injury, the patient recovered.

The action of the maggots may cause intense pain. Stewart (*145*) gives a case history of the infestation of a malodorous, suppurating scalp sore by *Phormia regina*. The patient was admitted to the hospital for treatment of the sores, and after the second treatment with a supersaturated sulphur wash—

> . . . the patient became very restless, working the fingers into the palms of her hands and alternately putting her hands to her ears. Soon she began to scream, acted frantic, and became nearly delirious. She was given a sedative without effect.

On taking the towel from the patient's head the nurse observed fly larvae, which had been forced into activity by the treatment, crawling over the towel, hair, and down the cheeks. The nurse estimates that she killed twenty-five or thirty larvae in the hour and a half she spent in removing them and still the hair and scalp remained full of them. Back of the ears the mass of living larvae was so great that they could almost have been spooned out. At this time the patient complained of a buzzing in the ears similar to that occurring when the ears are full of water, and said that she could not hear. The nurse then used toothpick swabs to remove the great quantity of larvae found in the pinnae of the ears.

Infestation of wounds may result fatally, especially when the etiological agent is *Wohlfahrtia magnifica*, *Callitroga americana*, or *Chrysomya bezziana*. The seriousness of the infestation depends upon the species involved, the number of parasites, the depth and extent of the damage, and the part of the body affected.

Though entrance is usually made through a sizable wound, it is not necessarily so. *Callitroga americana* may infest a minor injury, such as a scratch, a stubbed toe, or a cut received from trimming ingrowing toenails. Sheep and lambs often become infested through wounds caused by needlegrass (*Stipa* spp.). In fact, the maggots have been shown to be capable of entering the unbroken skin of guinea pigs and rabbits, and at least one human case of what appears to be this infestation has been recorded (Mazza and coworkers, *87*). *Wohlfahrtia magnifica* is said to enter wounds as small as those made by the bite of a tick. Secondary infestation by various species may take place through leprous, cancerous, syphilitic, and other types of sores and lesions.

The presence of maggots in wound tissue, however, does not always indicate a dangerous condition. Many of the Sarcophagidae, Calliphoridae, and Muscidae found in wounds are merely scavengers, and their presence may be actually beneficial. The widespread use of certain strains of blowfly and sarcophagid maggots in surgical treatment of suppurating wounds in the 1930's is a testimonial of this. The fact that what is supposedly a single species, for example *Phaenicia sericata*, may under certain circumstances be a scavenger and under others a serious parasite is hard to explain. The subject needs a great deal of further research.

### MYIASIS OF THE NOSE, MOUTH, AND ACCESSORY SINUSES

Two types of myiasis affecting the nose, mouth, and the accessory sinuses are known. The more serious of these, called peenash in India and bicheiro in tropical America, is caused chiefly by *Callitroga americana*, *Wohlfahrtia magnifica*, and *Chrysomya bezziana;* it often accompanies myiasis by the same species of a head injury, ulcer, lesion, or other traumatism. It usually begins with tickling or prickling sensations and a general feeling of uneasiness in the nasal region. The patient often reports having experienced a fly entering the nose at such a time that he was powerless to interfere, or having slept in the open during the daytime. The nose and face quickly become swollen, and intense headaches, usually accompanied by fever, develop. The breath becomes bad, and a discharge consisting of a mixture of pus and blood is passed through the nose. The patient is in intense pain, more severe at times, but more or less constant. If untreated, severe infestations often result in death. The septum of the nose may fall in,

the soft and hard palate may be pierced, the pharynx may be eaten away to the bone, and even the hyoid bone may be destroyed.

The second type, known as thim'ni or tamné in North Africa, where it is most abundant, is discussed under *Oestrus ovis*, its etiological agent.

### AURAL MYIASIS

Myiasis of the ears is often associated with that of the nose and mouth, with the same etiology. Maggots infesting the accessory sinuses of the nose may easily invade the ear either externally or through the Eustachian tubes. In at least one known case, a maggot, entering the ear through the tubal route, produced an abscess which, with the weakened condition of the patient following the expulsion of the larvae from his nose and sinuses, brought about his death. Sometimes, however, aural myiasis may develop independently. In such cases the fly involved is usually a semispecific or accidental myiasis producer, and the invasion is secondary to some pathogenic condition. In one case cited by Onorato (*96*), maggots of *Phaenicia sericata* were taken from an otherwise healthy ear; such an infestation had previously been considered impossible because of the deterrent effect of the earwax.

The symptoms of auricular myiasis are pain or discomfort accompanied by deafness and a ringing in the ear if the maggots are in the external meatus, and a bloody purulent discharge if they have entered the middle ear. Obviously, severe cases of aural myiasis, particularly those in which primary invaders are involved, may, if not treated in time, result in the loss of the organ affected.

### OCULAR MYIASIS

Myiasis of the eye and surrounding tissue may, like that of the ear, be concomitant with that of the nose and accessory sinuses, and with the same etiology. The destructive action of larvae of *Wohlfahrtia magnifica*, *Chrysomya bezziana*, *Callitroga americana*, and sometimes *Phaenicia sericata* and other species, may consume the entire organ if unchecked.

Two other types of myiasis may affect the eye. One type is the painful but otherwise usually not serious form of conjunctivitis caused by the first-stage larvae of *Oestrus ovis* or *Rhinoestrus purpureus;* the larva is similar in the two species and is discussed under *Oestrus ovis.* In the other, and more serious type, *Hypoderma* larvae, in the course of their wanderings through the body, enter the surrounding tissue or the eyeball itself and, particularly if they lodge in the posterior chamber, may bring about the destruction of the organ. This type is discussed more fully under the heading of *Hypoderma.*

In medical literature myiasis of the eye is usually called ophthalmomyiasis, a term proposed by Hope and later expanded by Behr to include three types, as follows: Ophthalmomyiasis externa, in which the orbit is affected but not the eyeball itself; ophthalmomyiasis interna anterior, to indicate invasion of the anterior chamber; and opthalmomyiasis interna posterior, to indicate invasion of the posterior chamber.

### MYIASIS OF THE ANAL REGION AND VAGINA

A number of cases of myiasis of the anus, perianal region, rectum, and vagina are on record. Many of them have occurred in persons who have slept or have been left in a helpless condition during the daytime either outdoors or in fly-infested rooms; some of them, however, may be due to the use of unsanitary toilets.

Dove (*34*) cites a case in Florida of an elderly woman, living alone, who fell and lay helpless for several days; when discovered, she was badly infested with screwworms which had entered the vagina and were active in the sacral regions and the navel. About a quart of larvae were obtained from the wounds. The case terminated fatally, although the author does not state how much might have been due to the maggot infestation and how much to exposure and other causes.

The attractant to the fly sometimes is a fetid discharge or a preexisting sore or diseased condition, such as a carcinoma. The various species of flies which may be involved in this type of parasitism include *Callitroga americana*, *Chrysomya bezziana*, *Wohlfahrtia magnifica*, and semispecific myiasis producers belonging to the families Sarcophagidae and Calliphoridae. Maggots invading the vaginal and rectal regions may be discharged with the urine or feces, and thus lead to a mistaken diagnosis of intestinal myiasis.

### MYIASIS OF THE BLADDER AND URINARY PASSAGES

Numerous instances, the oldest dating back to Plutarch, have been recorded of dipterous larvae invading the urinary passages and bladder of human beings. Cases have been reported in patients of both sexes and of all ages. Chevrel (*27*), in a detailed study of the subject, has summarized the work up to that time, and Mumford (*91*) has added the description of several more cases. Other scattered literature adds little information, except to indicate that this type of myiasis is an actual, though uncommon, reality.

It is possible that infestation may take place through the use of a catheter, a syringe used for douching, or some other instrument which has been stained with urine or other matter which, on decomposing, has attracted flies to oviposit. In the majority of cases, however, infestation is probably a result of natural exposure, such as might come from the use of unsanitary outdoor toilets or from sleeping during the daytime with the body exposed. In such an event the female fly may be attracted by discharges, especially those of an albuminous nature.

Chevrel believes that the eggs are deposited on the prepuce or the folds of the vulvar mucosa, where the moisture and warmth cause them to hatch rapidly. After hatching they feed on the discharges and gradually make their way upward through the urinary meatus. This upward journey seems to be made without irritation to the host. According to Chevrel, the ultimate stopping place of the larva is the site of the infection that attracted the parent flies, namely, the urethra in the case of gonorrheal patients and the bladder in the case of nephritics and diabetics. The mucopurulent secretions furnish the larvae with food; they obtain sufficient oxygen to supply their meager needs from pockets and folds in the urinary tract and in the bladder.

Urinary myiasis is accompanied by pains in the lower abdomen, especially in the area of the bladder or kidneys; urination is often

painful, difficult, or temporarily impossible without the aid of a catheter. In men it may be accompanied by painful erections followed by ejaculations which may expel some of the larvae. The number of larvae infesting a person is often small, especially in males; in some female patients the number of parasites has exceeded 50.

*Fannia canicularis* is the species most frequently involved, but *Musca domestica* is also an occasional etiological agent; others that have been recorded are *Fannia scalaris* and *Teichomyza fusca*. The *Fannia* larvae were mistaken by some earlier writers for isopod crustaceans.

### FURUNCULAR DERMAL OR SUBDERMAL MYIASIS

Furuncular dermal or subdermal myiasis is caused by specific myiasis-producing flies which enter either the unbroken skin, tiny perforations made in the skin, or the openings of hair follicles. The developing larva forms a boillike tumor, or furuncle, which opens externally to permit the larva to breathe. The furuncle may be very painful when the larva is feeding and may subsequently become infected with bacteria, or by the invasion of screwworms and other producers of traumatic myiasis. Death of the larva within the tumor often has serious effects as a result of bacterial contamination. The larva is capable of completing its development within the furuncle, after which it will emerge, drop to the ground, and pupate. After emergence of the larva healing is rapid if no complications are present.

Several species of flies, of different taxonomic groups, may cause this type of myiasis. Those commonly involved are *Dermatobia hominis*, *Wohlfahrtia vigil*, *W. opaca*, *Cordylobia anthropophaga*, and *Stasisia rodhaini*. *Callitroga americana* will produce a similar tumor, when the invasion is made by a very small number of larvae and through a very small puncture in the skin, or possibly through the unbroken skin; and the final stage of *Hypoderma* will likewise produce a furuncular swelling.

### CREEPING DERMAL OR SUBDERMAL MYIASIS

It has long been known that two genera of Diptera, *Gasterophilus* and *Hypoderma*, may be involved in a condition called variously as creeping disease, creeping eruption, larva migrans, and by other medical and vernacular names. Since the geographical distribution of the disease is more extensive than that of the flies supposed to cause it, other etiological agents were sought. It is now known that cases in Florida, Africa, and other tropical and subtropical regions are due to nematodes and not to fly larvae. Kirby-Smith, Dove, and White have discussed the situation in Florida in relation particularly to nematodes but also to insects. In general, multiple infestations in the outer layers of skin, contracted in areas extralimital for *Gasterophilus*, are probably nematode and not insect infections.

Human myiases involving *Gasterophilus* and *Hypoderma* differ greatly from each other. In *Gasterophilus* the tunnels appear as narrow raised lines which progress at one end and fade out at the other; they extend through the upper layers of skin in a serpentine fashion, often crisscrossing each other. The boring of the larva often occasions severe itching but no pain. *Hypoderma* galleries, on the

other hand, occur in the subcutaneous connective tissue, though from time to time they emerge toward the surface; the tunnels are broader and not so well-defined. The activity of the larva may cause severe pain. Each type is discussed in more detail under the heading of its genus. In both types man is an accidental host.

## ENTERIC MYIASIS

Under this heading will be considered myiasis of the stomach, of the intestine, or of both, it being impracticable for the most part to try to separate them. This type of myiasis is most representative of Patton's third group or accidental myiasis-producing flies.

Great care is necessary in diagnosing enteric myiasis. Undoubtedly many cases reported to be such, some of which become recorded in the literature, are attributed to contamination of stools or to cases not adapted to this interpretation of the facts. The horror of intestinal worms, in which category the layman usually includes maggots or almost anything wormlike, is so firmly implanted in the popular mind that the presence of maggots, actually or supposedly, in fresh stools is usually a source of alarm. One is likely to overlook the possibility that there was previous contamination of the chamber vessel, or that the maggots might have entered the rectum, vulva, or urinary passages or bladder, and in this way might have been passed with the feces or urine.

Contamination of the stools can easily be accomplished, especially by species of *Sarcophaga*, in which the maggots are produced alive, and in which the duration of the first two larval instars is often very brief. It may therefore be possible to find third instars resulting from subsequent contamination in stools no more than a day old. Furthermore, the mother fly will often drop her maggots through gauze or deposit them in places where they may crawl through cracks through which it would seem impossible for them to pass. A covered chamber vessel, therefore, is not necessarily maggot-proof, at least so far as *Sarcophaga* is concerned.

In relation to the work of both Komárek and Causey, the selection of experimental animals, both mammalian and arthropod, may be criticized. Dogs and cats are carnivores, and conditions within their digestive tracts are certainly not identical with those of the human. In regard to the Diptera used, Causey selected *Drosophila melanogaster*, *Phaenicia sericata*, *Phormia regina*, *Callitroga macellaria*, *Sarcophaga securifera*, and *Calliphora erythrocephala;* Komárek, *Calliphora vomitoria*, *Sarcophaga carnaria*, *Musca domestica*, and *Piophila casei*. It should be noted that *Sarcophaga haemorrhoidalis*, *Tubifera tenax*, and species of *Fannia*, *Muscina*, and *Megaselia*, the etiological agents involved in most of the best authenticated cases of enteric myiasis, are absent from both lists, whereas *Piophila casei*, which also belongs in that category, is mentioned by Komárek only in general and not in relation to any particular experiments.

However, one should not take the extreme view that enteric parasitism by fly larvae is impossible. The fact that *Gasterophilus* larvae develop normally as gastrointestinal parasites of the horse and related animals should disprove this theory. If the evidence is sufficient and

withstands a critical examination, we must admit the possibility of accidental parasites, in some cases and under certain conditions, maintaining themselves in the human digestive tract.

Komárek (*76*) and Causey (*26*) have attempted to disprove the possibility of infestation of the human digestive tract by fly larvae. The arguments of these authors are based on the premises, first, that the active normally free-living larvae (in contrast to *Gasterophilus*) cannot survive the relatively anaerobic conditions existing in the human digestive tract, and second, that the mechanical movements of the tract and the action of the digestive juices would destroy the larvae even if they could obtain sufficient oxygen. Komárek subjected larvae of various species of flies reported to be involved in intestinal myiasis to conditions that would simulate anaerobic conditions of the stomach and intestine; he also fed some living larvae to a cat. All the larvae perished. Causey used cats and dogs as experimental animals; in all cases the larvae "were found to be killed or immobilized in the stomach within 3 hours and, on passage into the intestinal tract, were eventually digested. In no instance could living larvae of any of these species be discovered in the large intestine or passed feces of the experimental animals."

The conclusions of Komárek and Causey are criticized by Riley (*120*). As that author points ont—

> a limited series of experiments may be wholly negative without justifying the disregard of many detailed reports by careful physicians and entomologists who have been well aware of chances of error involved. Similar negative results could be obtained by administering infective stages of cat ascarids to human beings. Children everywhere are exposed to innumerable opportunities to pick up infections of these worms and yet instances of their development in man are so rare as to be veritable medical curiosities. In these rare instances some abnormal condition of the individual has made it possible for the worms to maintain themselves. The possibility of this occurring in the case of fly larvae would seem fully established * * *.

Case records of enteric myiasis in man often indicate gastric and intestinal disturbances which have endured over a considerable period of time, sometimes years. This has sometimes been interpreted as suggesting, or indicating, that the larvae were reproducing paedogenetically within the digestive tract. Following Riley's suggestion, one might conclude that in such cases digestive disturbances of another nature may modify conditions within the digestive tract to such a degree that larvae not normally capable of living there could endure the new conditions. Ingested air might supply the oxygen for at least part of the journey through the alimentary canal; flatulence is usually associated with this form of myiasis. If oxygen is not available at all times, it must be considered that even active maggots are capable of undergoing periods of suspended activity. Extended periods of infestation, however, may be explained in some instances by reinfestation. Sometimes the habits of the patient are such that this is a strong possibility. That the presence of fly larvae in the digestive tract could produce symptoms such as are usually ascribed to enteric myiasis, notwithstanding Causey's opinion to the contrary, should seem reasonable when one considers the effect the rasping action of savage mouth hooks might have on the intestinal wall and the possibility of toxic and infective effects following.

A discussion of the symptomatology and general pathogenesis of enteric myiasis is given under the species involved, particularly *Fannia, Sarcophaga haemorrhoidalis*, and *Muscina stabulans*. The following symptoms seem to be fairly characteristic, according to published case records. The patient suffers from general malaise and weakness; his face is pale, and he has a complete loss of appetite. Nausea and vomiting occur at the onset; sometimes larvae are expelled with the vomitus. Severe gastric pains may be present and may be accompanied by bloating and tremulous motions in the area of the stomach and upper intestine; there may also be dizziness and violent headaches. Sometimes, particularly in children, violent spasms and epileptic fits may occur. The symptoms are those of an acute gastritis or enteritis; they have been described as those of cholera morbis. They disappear with the passing of the larvae.

Infestation probably comes through the food, though sometimes possibly through the drinking water, from soiled hands, direct deposition in the mouth, or other means. Larvae may be passed with the feces, sometime in enormous numbers, or may be expelled in vomitus. Many cases have been described in the literature. A particularly obstinate one, involving unnamed species of three genera, is described by Herms and Gilbert (*57*); others are cited at various places in the text.

### ATTACKS BY BLOODSUCKING MAGGOTS

Though not myiasis in the strict sense, bloodsucking by certain maggots is mentioned as a related phenomenon. Several species of muscoid flies belonging to unrelated groups of genera parasitize nestling birds in this manner, but only one species, the calliphorid *Auchmeromyia luteola*, attacks man and, unlike all the true myiasis producers, is apparently specific to man.

## LIFE HISTORIES

Though life histories of Diptera vary considerably, they conform more or less to a given pattern. All flies have complete metamorphosis. The female usually produces eggs, though larvae in all stages of development and, indeed, pupae are sometimes produced. The larvae feed on a wide variety of substances; they may be plant feeders, scavengers, predators, parasites, or bloodsuckers. Some live in water, some in a semiaquatic medium, some on land, some in decomposing plant or animal tissues, and some internally or externally on the body of a host. The larval stage is the one actively involved in myiasis. As a rule the larva passes through three developmental stages, or instars, though variations from this number may occur. In most Diptera the various larval instars of a given species bear a general resemblance to one another. Conditions of pupation vary with the species. The pupa in the higher flies is capsulelike in appearance; in the lower flies the form varies considerably. Some species may complete a generation within 2 weeks or less, while others require a year or more. In temperate regions hibernation may take place in any stage of the life cycle, but the stage that hibernates seems to be rather definite for any given species.

## MORPHOLOGY

### ADULT

The body of the adult fly is divided into three parts—head, thorax, and abdomen. Each division is composed of three or more segments, although in the head the segments are fused and their exact number has not definitely been settled. The term "segment" may be applied to the divisions of the body as a whole or to those of an appendage, such as an antenna, a palpus, or a tarsus. When a segment, as in the antenna, is subdivided, or when segments have partially fused so as to lose their identity though retaining a semblance of it, the term "annulus" is applied to the subdivision.

The integument is more or less hardened by the deposition of some substances of uncertain chemical nature. This hardening is often called chitinization, although it has been shown that this term is erroneous, chitin itself being not particularly hard; sclerotization is the proper term. Sclerotization takes place in definite areas which are called sclerites. The terms applied to certain sclerites and to bristles located on them are in considerable use in the taxonomy of the muscoids.

The body of a fly or of its larva is very rarely completely bare. Several terms applied to the vestiture need definition. Pubescence is very short, fine, downy hair that often escapes notice in casual examinations; the usual hairy covering of the adult consists of pile, which is soft and rather dense, and setulae, which are coarser. The large, coarse, hairlike structures, which tend to assume definite patterns of distribution and which are very important in the adult taxonomy, are the bristles (macrochaetae). Color patterns in the adult may be due to pigments in the integument, but often they are derived from dense pilose coverings. Another common source of color is the pollen, a fine dustlike substance which may cover parts of the integument and give it a bloom, often vivid enough to conceal the ground color.

Unfortunately, separate systems of terminology have come into use in taxonomy and morphology, with the result that often a term used in description does not refer to the real morphological equivalent. In order to avoid complications, the terminology of the taxonomists is strictly adhered to.

The head (fig. 1) offers a considerable number of characters of taxonomic importance. From an anterior view, the part between the eyes is known as the front above the antennae and as the face between the antennae and the oral margin. The upper part of the front is known as the vertex; in its center there is a well-marked sclerite, the ocellar triangle (*ot*), on which the three ocelli (*oc*) are situated. In the higher flies the front is divided longitudinally into three regions. The median region is the frontalia or frontal vitta (*frl*); to each side of it is a parafrontal (*pfrl*) which is continuous with the similarly located parafacial (*pfcl*) of the face. The parafrontal and parafacial together form the ocular orbit, a term which is also used in the lower flies, in which the parafrontals and parafacials are not differentiated, to denote a similarly located region. In the higher muscoids the median region of the face is separated from each parafacial by the ridgelike facial (*fcl*) and a suture, and is divided into

two regions, the clypeus (*cl*) and the epistoma (*ep*), the line of separation between the two being a suture which is often obscure. The clypeus may be flush with the rest of the face, or it may be sunken underneath the antennae to form two antennal foveae, or it may be completely sunken below the level of the facials; the middle of the clypeus, especially when that region is sunken, may be elevated into a median keel or carina (*car*). The epistoma often projects forward,

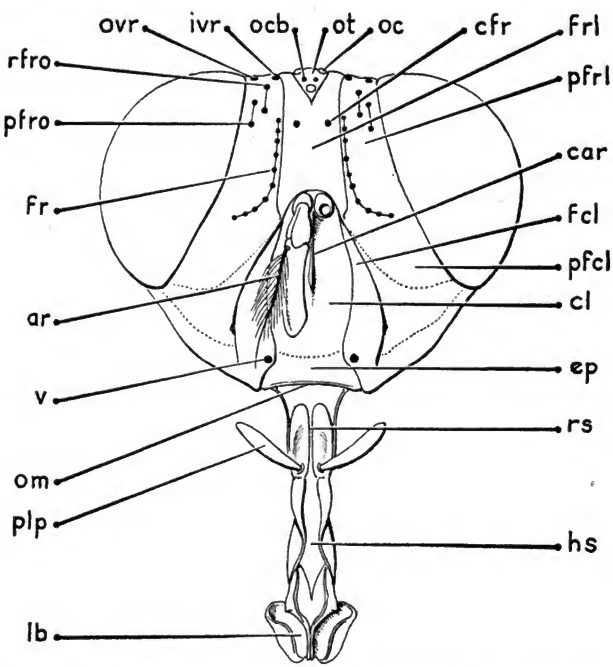


FIGURE 1.—Diagrammatic drawing of the head of a muscoid fly, from front view. For explanation of abbreviations, see pages 17–19.

although it may be level with the clypeus or may recede; it is bounded below by the oral margin (*om*).

In general the bristles of the head are named from the sclerites on which they are located. An exception is the vibrissa (*v*), usually a very strong bristle on each facial near the union of the clypeus and the epistoma, or near the oral margin when the clypeus and epistoma are not differentiated. The facials may bear, in addition to the vibrissae, a series of short, ascending bristles, in one or more rows, extending part way or fully to the bases of the antennae; sometimes there may be one

or several accessory vibrissae near the bases of the true ones. The parafacial often bears one or more bristles. There is usually one, sometimes two, pairs of ocellars (*ocb*) on the ocellar triangle; the vertex may have an inner (*ivr*) and an outer (*ovr*) pair. The bristles most commonly occurring on the frontal vitta are a pair of cruciate frontals (*cfr*) directed inward and crossing each other. The bristles of the parafrontals are highly important. They consist of the frontals (*fr*), a row of inwardly directed bristles next to the margin of the frontalia; the proclimate fronto-orbitals (*pfro*), usually two but sometimes more or less, and directed forward; and the reclinate fronto-orbitals (*rfro*), directed backward.

The dipterous antenna is variable in form and shows many graduations from the long many-segmented filiform or moniliform antenna of some nematocera to the highly specialized three-segmented antenna of the muscoid. In the three-segmented type the third segment bears on its dorsal surface and usually near its base a bristlelike arista (*ar*) which, upon careful examination, may be seen to be composed of two or three segments, an indication of its composite structure as a remnant of the missing terminal segments of the antenna. The form of the arista is of considerable taxonomic value: it may be bare, pubescent, or pectinate or plumose part way or to the apex. In the many-segmented antenna the segments beyond the second are often fused, forming an apparently annulated third segment; in some cases, the true third segment is much larger than those that follow, the latter located at the apex of the third to form a style.

The proboscis consists of three parts—the rostrum (*rs*), the haustellum (*hs*), and the labella (*lb*). The rostrum bears a pair of sensory palpi (*plp*). Flies that take no food in the adult stage may have the proboscis reduced to rudiments (cf. figs. 52 and 61); in the others it may be modified in accordance with the food habits. Bloodsucking species usually have a long haustellum and small or rudimentary labella, or the mouth parts are in other ways modified for piercing and for sucking blood; other species that are flower feeders might have an elongated haustellum with small labella.

The mesothorax, or intermediate thoracic segment, is greatly developed at the expense of the other two segments. The sclerites of the prothorax which are most clearly evident are the unpaired prosternum, which lies between the anterior coxae and may be bare, hairy, or bristly, and the paired propleura (*ppl*), which are usually bare except on the lower part, but which may be hairy. The mesothorax (fig. 2) is a rather complicated structure. The areas used in the descriptive matter that follows can best be located by means of the illustrations. On the dorsal side, above the wing bases, are the paired humeri (*hm*), the mesonotum (*msnt*) which is divided into two parts by the mesonotal suture (*sut*), the paired notopleura (*npl*) and postalar calli (*pac*), the scutellum (*scut*), and the postscutellum (*pscut*). The pleural areas on each side below the wing base are the mesopleuron (*mspl*), the sternopleuron (*stpl*), the pteropleuron (*ptpl*), and the hypopleuron (*hpl*). The metathorax, like the prothorax, is greatly reduced, but a pair of rudimentary wings, the halteres (*halt*), arise one from each metapleuron (*mtpl*). The prothorax lacks spiracles; there is, however, a mesothoracic pair (*mss*) located between the propleura and the mesopleura, and a metathoracic pair (*mts*) between the hypopleura and the metapleura.

The prosternal, propleural, mesopleural, pteropleural, sternopleural, and hypopleural bristles bear the names of the sclerites on which they are situated. In addition to the posterior row of mesopleurals, that sclerite sometimes also bears one or more bristles below the mesothoracic spiracle, the stigmatic bristles (*st*). The humerus and notopleuron may bear humeral (*hb*) and notopleural (*npb*) bristles respectively.

The arrangement of the bristles of the mesonotum and scutellum is more complicated. The mesonotum, when its complement of bristles is complete, bears four rows on each side of the median line; these bristles are, from the innermost outward, the acrosticals (*acr*), dorsocentrals (*dc*), intra-alars (*ial*), and supra-alars (*sal*). These may be designated, according to their position, as presutural or postsutural; the acrosticals immediately in front of the scutellum are the

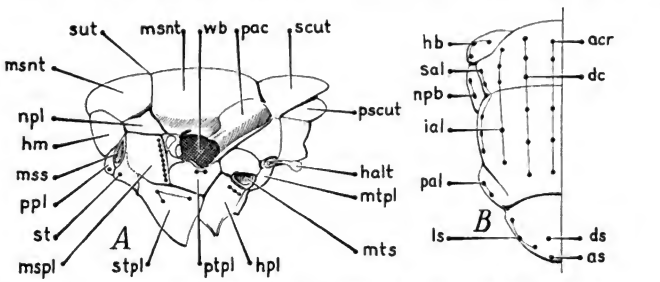


FIGURE 2.—Diagrammatic drawing of the thorax of a muscoid fly: *A*, Side view; *B*, right half, dorsal view. For explanation of abbreviations, see pages 19–20.

prescutellars. The bristles of the postalar callus are the postalars. (*pal*). The scutellum may bear a row of lateral scutellars (*ls*), not necessarily all on the same horizontal plane; a pair, usually small, of apicoscutellars (*as*); and one or more pairs of discoscutellars (*ds*).

The Comstock-Needham system is used in the terminology of the wing venation (figs. 3 and 4). There are eight principal longitudinal veins. The first, or costa (*c*), forms the anterior margin of the wing but usually disappears near the wing apex. The second, or subcosta (*sc*), is for practical purposes unbranched, but is usually connected to the costa by the humeral cross vein (*h*). The third, or radius (*r*), in the primitive wing branches dichotomously to form the branch $r_1$ and the radial sector (*rs*), the latter branching dichotomously and its branches in turn doing the same, to form veins $r_2$, $r_3$, $r_4$, and $r_5$, respectively. The fourth, or media (*m*), is hypothetically four-branched, though for practical purposes it may be considered three-branched ($m_1$, $m_2$, and $m_3$), the branching taking place dichotomously. The fifth vein, or cubitus (*cu*), divides into two branches, $cu_1$ and $cu_2$. The three remaining veins, all unbranched, are the first, second, and third anal veins. The first of these, when present, is usually represented merely by a fold; so the apparent first in most wings is actually the second. In addition to the humeral, there are several cross veins,

of which the radio-medial (*r-m*) and the medio-cubital (*m-cu*) need to be mentioned.

The more primitive dipterous wing (fig. 3) is so close to the hypothetically primitive type that it presents relatively little difficulty in its interpretation. The muscoid wing (fig. 4) can easily be understood if one considers that its venation is a reduction of the more primitive type through the disappearance of certain veins and the fusion of

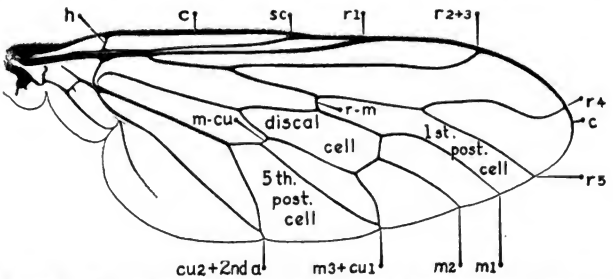


FIGURE 3.—Wing of *Thereva*, illustrative of the more primitive type of venation.

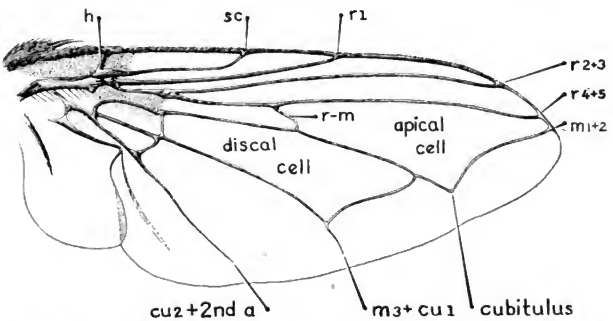


FIGURE 4.—Wing of *Callitroga americana*, illustrative of the muscoid type.

others. According to the Comstock-Needham system, the symbols used to indicate such fusion simply compound the fused elements. For example, $r_{2+3}$ means the undivided second and third branches of the radius; $m_{3+}cu_1$ means the fusion of the third branch of the media with the first of the cubitus. In the higher muscoids, vein $m_{1+2}$, after its separation from $m_3$, bends, sometimes broadly, sometimes abruptly, toward the radius; when this bend is well marked, it is known as the cubitulus.

Certain other structures on the wing or associated with it are of taxonomic importance. Series of setulae may occur at various places—for instance, on the stem of the radius basad of the humeral cross vein, on vein $r_1$ beyond the origin of the radial sector, or on vein $r_{4+5}$

beyond the point of its separation from $r_{2+3}$ (cf. figs. 4 and 13). In certain acalypterate muscoids the costa may be broken near the humeral cross vein or near the apex of vein $r_1$, or in both places. In some cases a strong costal spine (cf. fig. 13) occurs near the apex of vein *sc*. Certain modifications of the wing membrane, such as the development of macrotrichia, or spurious veins or folds, may occur; those pertinent to this work are treated in the proper place in the text.

The wing articulates with the body on several sclerites (fig. 5), three of which are referred to in the descriptive part of this work. At the base of the wing, along the costal margin, are two scalelike sclerites, the epaulet (*epl*), which is setulose and situated next to the body, and the basicostal scale (*bcs*), which is bare and situated next to the base of the costa. The subcostal sclerite (*sscl*), best seen from the under side of the wing, lies at the base of the subcosta and radius. Each wing is connected basally with the thorax by the squamae or calypteres which are best developed in the higher muscoids and in a few isolated groups such as the Tabanidae. There are two squamae associated with each wing, an upper or alular squama (*asq*) and a lower or thoracic squama (*tsq*).

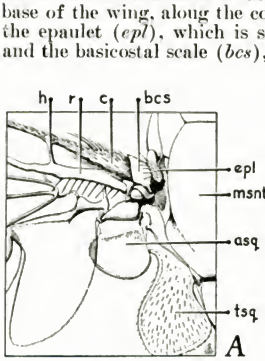


FIGURE 5.—Structures at the wing base of a muscoid fly: *A*, Dorsal surface; *B*, ventral surface of costal region. For explanation of abbreviations, see page 22.

The leg consists of five well-defined parts—the coxa, trochanter, femur, tibia, and tarsus. The tarsus in most Diptera is five-segmented; the basal segment, or basitarsus, is usually the longest and is sometimes enlarged.

The number of visible abdominal segments in all the Diptera is greatly reduced from the theoretically primitive number of 12. The usual number in the muscoids, aside from those forming the genitalia, is 4 or 5; these are called the pregenital segments, and, when the number is 4, the second and third are designated as the intermediate segments. A typical abdominal segment consists of 2 parts, a tergite (dorsal sclerite) and a sternite (ventral sclerite). In the higher Diptera the lateral plates (pleurites) that occur in many of the more primitive insects, as well as in a modified form on the dipterous thorax, have disappeared; as a matter of fact, in the muscoid flies a tergite usually extends over the sides of the abdomen, and its margins may meet ventrally, thus partly or even completely obscuring the sternite. The genital segments, or genitalia, are much used in the taxonomy of certain groups of flies, but their use usually requires the spreading and the careful examination of the parts. In the males the genital segments form a structure, often somewhat bulky, called the hypopygium; it ends in a pair of posterior forceps.

In the muscoids the arrangement of the bristles of the abdomen is of some taxonomic importance, but not nearly so much as on the head

or thorax. The bristles on or near the posterior margin of the segments are the marginal abdominals; those in a median position in relation to the anteroposterior axis are the discal abdominals. Both discals and marginals may occur either in isolated pairs or in rows; there may be more than one pair or row, serially arranged, of discals to a given segment.

## LARVA

The typical muscoid larva (fig. 6, *A*), such as that exemplified by *Sarcophaga*, *Musca*, and *Calliphora*, is a cylindrical, headless, legless maggot, usually broader on the posterior than on the anterior half, strongly tapering anteriorly, and with a more or less truncate posterior face. The two prominent posterior spiracles impress one unfamiliar with maggot anatomy as being eyes, and for this reason earlier writers have sometimes confused the anterior end of the larva with the posterior.

There are 12 apparent body segments, including the cephalic (*cs*) and the anal segments (*8ab*), both of which, though apparently simple, are of a compound origin. The first or cephalic segment is short and conical; ventrally, it is armed with a pair of strong mouth hooks (*mh*). The first thoracic (prothoracic) segment (*1tho*) bears an anterior spiracle (*asp*) on each side; this structure is typically tubercular, its apex terminating in a varying number of processes each of which ends in a spiracular opening. The anterior spiracle is nonfunctional in the first instar, although it can sometimes be seen under the integument. The cuticle of the thoracic and abdominal segments may be bare; usually, however, it bears rows or bands, either complete or incomplete, or areas, of spines along the anterior (*spa*) or posterior (*spp*) margin, or both, of certain segments. The last abdominal segment (*8ab*) is typically more or less truncated posteriorly; usually its posterior face is flush or convex, though sometimes there is a prominent slit or depression in which the posterior spiracles are located (fig. 6, *C*). Above and below this depression, or, if it is absent, the area which it would occupy, are a number of tubercles, typically 3 above and 3 below on each side. To each side of the anus is a prominent anal protuberance (*ap*).

The structure of the posterior spiracle (fig. 6, *D*) is of great importance in larval taxonomy. The spiracle, or spiracular plate, usually has an outer strongly sclerotized area, or peritreme (*per*), which may completely encircle the spiracle or may open ventrally. In a ventral position there often occurs a rounded structure, the button (*bt*); this may lie in the opening of the peritreme, or may be surrounded by that structure, or may be completely within its inner margin. The respiratory openings are the respiratory slits (*sl*), with three in the third-stage larva; these may be straight, curved, or sinuous; occasionally one or more of the slits may be fragmented into two or more parts. Sometimes there are breaks in the membrane between the slits. The number of slits is usually considered indicative of the larval stage, one for the first, two for the second, and three for the third. In drawings it is customary to show both spiracles or to give some indication as to their distance apart and relative position in respect to each other, since these relations are often of taxonomic value.

The internal skeleton of the head region (cephalopharyngeal skele-

ton) (fig. 6, *B*) is often visible through the translucent anterior end of the maggot, or at least can be seen by mounting or clearing. Since this structure, evidently of integumental origin, is sloughed off with

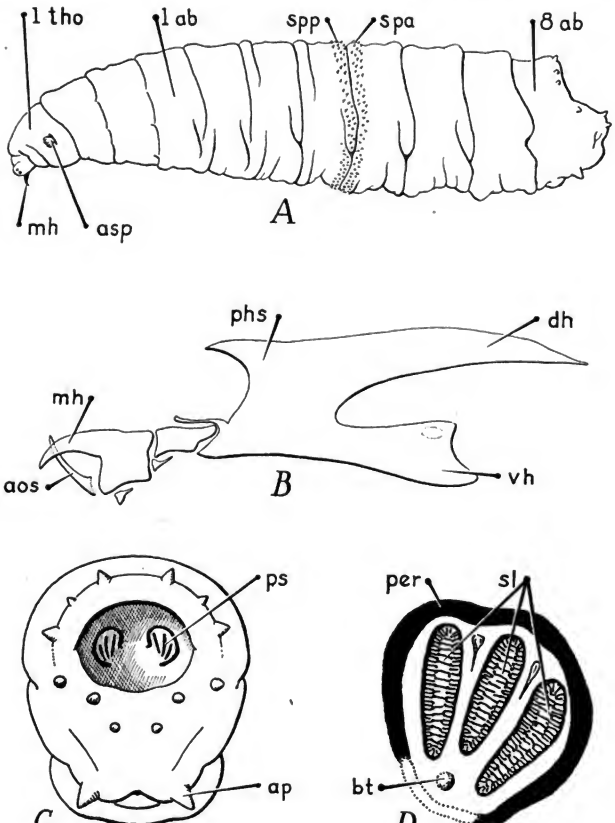


FIGURE 6.—Diagrammatic drawing of the mature larva of a muscoid fly: *A*, Lateral view; *B*, cephalopharyngeal skeleton; *C*, posterior view; *D*, a posterior spiracle. For explanation of abbreviations, see pages 23–25.

each molt, it can often be recovered from shed larval skins or from the inside of the empty puparium. Two main parts are used considerably in taxonomic studies. The mouth hooks (*mh*), sometimes called the labial sclerite, are typically two clawlike or hooklike structures, often

of characteristic form, which may, especially in the advanced instars, be fused into one; these replace, in function, the mandibles of the more primitive fly larva. In some cases an accessory oral sclerite (*aos*) is present. The pharyngeal sclerite (*phs*) is a relatively large winglike structure bearing an upper or dorsal horn (*dh*) and a lower or ventral horn (*vh*).

Deviation from the typical form, as above described, is common. In the larva of *Fannia*, for example, the body is greatly flattened, the individual segments are provided with a number of more or less pinnate processes, and the posterior spiracles are raised upon tubercles, with the button, upon superficial examination, often appearing as a fourth spiracular opening. In *Teichomyza* and *Drosophila* the posterior spiracles are at the end of a pair of long stalks. In oestrids, hypodermatids, gasterophilids, and certain calliphorids, the larva is grublike.

In the lower families of Diptera, the larvae are quite different from the muscoid type. Usually a distinct head which may be quite complicated in structure (cf. *Sylvicola fenestralis*, fig. 87) is present. The body form is extremely variable, but is usually not maggotlike. Usually, as in the muscoids, the larva is amphipneustic; that is, with a pair of respiratory spiracles near each extremity; however, certain larvae retain the more primitive peripneustic type, with schematically a pair of spiracles to each segment. Sometimes, as in *Tubifera*, extremely long posterior respiratory tubes are present. The body may have numerous modifications; these, together with the special terminology applying to them, are discussed at the proper place in the systematic text.

## TECHNIQUE FOR REARING, PRESERVING, AND SHIPPING

Many important records of myiasis-producing flies are lost because of the improper handling of the material obtained. The following paragraphs attempt to give only the minimum of entomological technique and cannot by any means be considered a complete guide for rearing, collecting, and preserving insects; it is hoped, however, that they will serve the purpose of placing larvae and adults obtained from cases of myiasis in the hands of competent specialists in a condition in which the material can be properly studied and determined.

In the United States, the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington 25, D. C., maintains an identification service; in some other countries a similar service is available.

### REARING

Since our knowledge of the taxonomy of immature forms of myiasis-producing Diptera is so fragmentary, determinations of such material often cannot be made with any degree of security. It is necessary, therefore, whenever possible to rear some to the adult stage. If there is sufficient material of what might be assumed to be the same species, some specimens should be preserved (see directions); the others may be reared.

Larvae should be removed with as little injury as possible and, as a rule, handled no more than necessary. If practicable, it is best to remove them with a forceps from the wound before any antiseptic has been applied. If an antiseptic has been used, they should be washed quickly in normal salt solution.

Rearing procedure depends largely on the habits of the parasite. In general, it is much more difficult to rear obligate parasites than facultative ones. Of the facultative parasites, breeding of the carrion feeders requires precaution against contamination of the culture medium by other species. There is always some danger that meat obtained from stores has been previously blown; moreover, breeding conditions should be such as to guard against a subsequent blowing. To cover the breeding medium with cheesecloth or gauze, even if double-layered, is not always sufficient. It is well known, for instance, that females of some species of *Sarcophaga* will drop their larvae through gauze or netting, or place them where they can crawl through the material. Patton (*102*) says that in India glass jars covered with glass lids, the edges of which were carefully vaselined, were not adequate to prevent contamination.

Directions given here are only complete enough for the rearing of partly developed larvae to the adult stage. If it is desired to rear successive generations of any of these flies, the original sources cited should be consulted.

## SPECIFIC MYIASIS PRODUCERS

Specific producers of myiasis, being obligate parasites, are unable, as a rule, to live on any medium other than the tissues of a living animal. The various warble flies and botflies (Oestridae, Gasterophilidae, Hypodermatidae, and Cuterebridae) remain attached to their hosts until ready to pupate; if artificially removed they will die, because they are still immature. Such larvae should therefore be preserved in alcohol, as it is useless to try to rear them. Mature larvae that have left their host will pupate if transferred to a box containing some damp earth. On the other hand, some Calliphoridae and Sarcophagidae, even though obligate parasites, can be reared to maturity from partially developed larvae.

**Wound-infesting species.**—Patton (*101*) has succeeded in rearing *Chrysomya bezziana* by transferring the larvae to wounds in experimental animals, and Melvin (Galtsoff and coworkers *44, p. 412, 413*) recommends a similar technique for *Callitroga americana* and *Sarcophaga bullata*. Melvin, using rabbits, placed the larvae in a wound made by cutting with the scissors a plug 1 inch in diameter out of a fold of skin in the rump; the wound was then covered with a piece of moist cotton held in place by adhesive tape, and the rabbit kept in a cage 20 inches long by 4½ inches wide. The width of the cage is important; it should be narrow enough to prevent the rabbit from getting its head to the wound to destroy the larvae.

To rear third- or even second-stage larvae of species other than *Chrysomya bezziana*, however, various workers have shown that a living host is not necessary. *Callitroga americana* larvae can mature on fresh rabbit or guinea pig carcasses at a temperature of about 90° F., and newly hatched larvae produce at least a small percentage of undersized, though otherwise normal, adults on fresh lean

beef or hard-boiled hen's eggs at 99°. According to Melvin and Bushland,[3] good results may be obtained in breeding successive generations with the following formula:

| | | |
|---|---|---|
| Milk | ml | 750 |
| Citrated calf's blood | do | 250 |
| Formaldehyde | do | 0.5 |
| Ground lean beef | g | 500 |

If these ingredients are mixed thoroughly in a 6-quart enameled pan and a piece of cotton (about 10 grams) is rolled into the mixture to form a raft, it will serve as a breeding medium for 2,000 to 3,000 newly hatched larvae and have the outstanding merit of doing away with objectionable odors, even when the larvae are mature. Breeding should be done in a warm room, at a temperature of 85° to 100° F.

The larvae should be allowed to escape into trays shallowly filled with sand, from which they may be transferred for pupation to jars partly filled with sand half saturated with water.

**Wohlfahrtia vigil.**—Although the females of this species could not under ordinary conditions be induced to larviposit on any but living animals, larvae were successfully reared on fresh meat by Ford (*37; 40, p. 324*) who gives considerable information on the rearing methods. The following is an abstract of Ford's method.

A supply of unblown meat may be maintained by placing a rabbit in the refrigerator immediately after it has been killed. Pieces of the muscle are placed in a petri dish to receive the larvae, and fresh pieces should be added from time to time, as the maggots will not thrive on stale meat. It is best to put several larvae in one dish. The petri dishes should be securely covered and placed in a dark cupboard; before time for pupation the whole mass should be transferred to a quart fruit jar half filled with damp sawdust.

## NONSPECIFIC AND ACCIDENTAL MYIASIS PRODUCERS

Cadaver-feeding Calliphoridae and Sarcophagidae are, in general, easily reared. Ground, lean beef makes a good breeding medium; however, hamburger purchased from markets should not be used, since it may contain too much fat, or may already have been blown. As a further precaution against previous blowing, meat should be obtained from the center of a large piece, and, of course, the grinder should be freshly cleaned.

Wide-mouth jars covered with two or more layers of gauze make satisfactory breeding cages, if kept in a fly-free place. Twenty larvae will thrive on 10 grams of meat and maintain a pH suitable for development. Enough moist sand should be placed in the jar prior to pupation to allow the maggots to burrow in.

Patton, in India, found it necessary to wrap the meat in several layers of paper, or to place it in a paper bag, in order to avoid contamination from outside. When so treated, the mature larvae will attempt to escape, but if fresh paper is added and the whole carefully tied on, they will pupate within the bag. Care should be taken lest the bag become soaked with the fluid of the decaying meat, in which

[3] MELVIN, R., and BUSHLAND, R. C. A METHOD OF REARING COCHLIOMYIA AMERICANA C. AND P., ON ARTIFICIAL MEDIA. U. S. Bur. Ent. and Plant Quar. ET–88, 2 pp. 1936. [Processed.]

event some of the larvae within might escape, or others from outside gain entrance to the bag.

For Sarcophagidae and some other Diptera, Lopes (*84*) has used a nutritive medium, common in bacteriological technique, consisting of 10 parts of nutritive agar to 1 part of normal horse serum. This medium may be kept in 50-ml. ampules, dated, and thus preserved for months. The puparia will be formed on the surface of the medium or the walls of the tube.

Special directions for rearing many other flies, including Tipulidae, Phoridae, *Psychoda*, *Tubifera* (*Eristalis*) and other Syrphidae, *Pollenia*, *Stomoxys*, *Musca*, *Muscina*, *Piophila*, and *Drosophila*, are given by Galtsoff and coworkers (*44*).

## PRESERVATION AND MOUNTING

Larvae may be killed by dropping them into water near the boiling point and allowing it to cool. Some larvae may be mounted dry, but the technique is not simple; they should never be pinned in the same fashion as an adult. The simplest way of preserving insect larvae is to put them in 70- to 80-percent alcohol. For dipterous larvae alcohol alone is sufficient; if, however, glycerol is added at the rate of about 1 part to 25 parts of 80-percent alcohol, it will keep the larva moist should the alcohol evaporate. Glycerol is objectionable for use with larvae of some other orders, in which the hair pattern is of great value in identification.

The best way to preserve adults is to mount them while fresh on insect pins. Only standard, noncorrosive pins should be used; in normal times these may be purchased from any dealer in entomological supplies. In pinning flies, the pin should be inserted through the right side of the thorax, at a sufficient distance from the edge of the body so that the sides of the thorax will not break, yet not so far to the left that the bristle pattern of that side is disturbed (fig. 7, *C*). About one-fourth the length of the pin, or enough to enable one to handle the specimen without touching it with the fingers, should extend above the insect. The size of the pin should depend on the size of the specimen. It is dismaying to see a small fly speared with a heavy pin and the thorax ruined; it is likewise annoying to find a heavy-bodied fly on a 00 pin. For general purposes, number 2 or 3 pins are best.

There are several ways of mounting small flies, and each method has its adherents. The one most commonly favored is to cut a small triangle of light white cardboard, insert the pin through the base, and attach the insect to the apex (fig. 7, *B*). A large triangle is unsightly; a desirable size is about 1.5 mm. at the base by 7–8 mm. long. Triangles may be purchased from supply houses, or, if they are needed in quantities, punches are available. Balsam or shellac is satisfactory for attaching the insect to the point of the triangle, although some prefer a more quickly drying adhesive. In mounting on triangles, one should take care to limit the adhesive to structures on one side of the insect, so as to leave the whole of one side intact and undamaged.

If proper mounting equipment is not available, the flies may be preserved in pill boxes between layers of Cellucotton, soft tissue paper, lens paper, or a similar material. Tin boxes should not be used, especially in warm, wet climates, where mold and mildew are factors in

deterioration. Ordinary cotton should not be used for packing in pill boxes, since its fibers are liable to become entangled with the legs and wings of the fly. Gelatin capsules or cork-stoppered vials may be used instead of pill boxes, with the insects held in place by Cellucotton or a similar material. Insects that have dried may be relaxed by being placed on moist sand in a tight container until they are moist enough to be handled without breaking; then they may be mounted in the usual way.

For a simple killing jar, a small amount of calcium, sodium, or potassium cyanide, placed in a large shell vial and held in place by

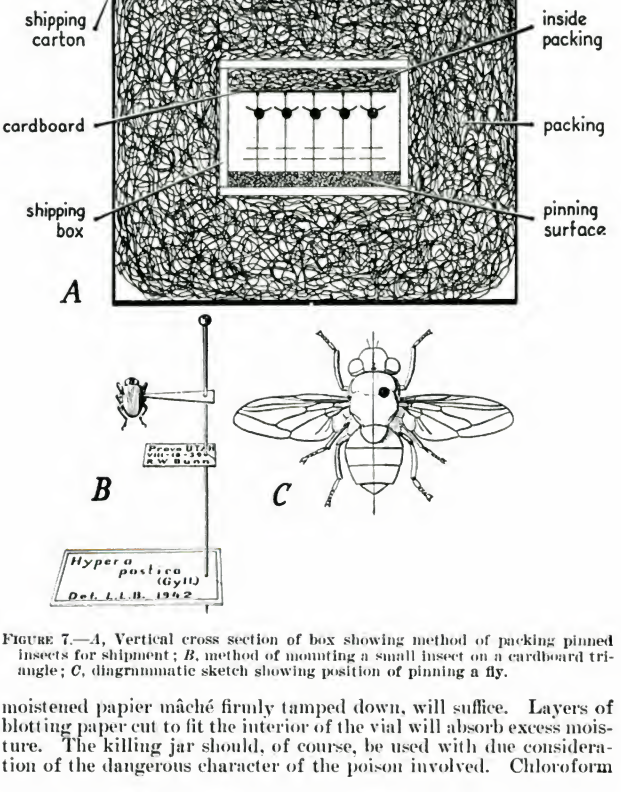


FIGURE 7.—*A*, Vertical cross section of box showing method of packing pinned insects for shipment; *B*, method of mounting a small insect on a cardboard triangle; *C*, diagrammatic sketch showing position of pinning a fly.

moistened papier mâché firmly tamped down, will suffice. Layers of blotting paper cut to fit the interior of the vial will absorb excess moisture. The killing jar should, of course, be used with due consideration of the dangerous character of the poison involved. Chloroform

or ether may be used as a killing agent, but the liquid should not be allowed to come in contact with the insect.

Insects should be stored only in a tight wooden box. Metal boxes may permit mold and decay, particularly in warm, damp climates. Boxes that are not tight will permit entrance of dermestids, psocids, and other pests which will destroy the collection. Naphthalene flakes, paradichlorobenzene, or a mixture of the two, will act as a serviceable repellent for the pests. Carbon disulfide is an effective, though highly inflammable and ill-smelling, fumigant. A cigar box may be made fairly satisfactory for temporary storage, if repellent is placed in it and the cracks are sealed with an adhesive tape. All crystals of repellents should be removed before the box is packed for mailing.

## PACKING AND SHIPPING

Specimens obtained from myiasis patients are valuable, and all reasonable care should be taken to prevent their loss and breakage in the mails. If a series of larvae and reared adults is obtained, not all the specimens of a series should be trusted to one shipment. A tragic example of failure to observe this precaution is on record. Onorato (*96*), after accumulating considerable material over a period of years, sent it to the Italian dipterist, Bezzi, for determination, and one lot, including all the material from certain cases, was lost in a train wreck before reaching its destination. Onorato's work would have gained considerably in value had these determinations been available. Because of the danger of loss or breakage, it is well to avoid shipment at times of heavy mail movements, as for example near the Christmas holiday season.

For shipping pinned material (fig. 7, *A*) a wooden or heavy cardboard box deep enough to accommodate the pins should be used. The bottom of the box should be lined with cork, balsa wood, double corrugated cardboard, fiberboard, or some other material of such a texture that the pins can be driven into it and held firmly. This pinning surface should itself be firmly attached to the bottom of the box. The pins should be driven into the pinning surface to such a depth that there will be no reasonable danger of their working loose. If there is any appreciable space between the heads of the pins and the top of the shipping box, a piece of light cardboard, cut to the size of the interior of the box, should be laid upon the support formed by the pinheads, accessory empty pins being used to complete the support, if necessary. The space between the cardboard and the top of the box should be filled with Cellucotton or some similar material which will hold the cardboard firmly in place; this material must not, however, be of such a nature that fragments of it will seep down around the edges of the cardboard and become entangled with the insects.

It is best to wrap the shipping box in paper (newspaper will do), and then to place it in a corrugated cardboard box or carton large enough to accommodate a protective layer of loose cotton, excelsior, frayed or crumpled paper, or some other packing material. The thickness of this layer may depend upon the size of the shipping box; for a cigar box it should be at least 2½ inches on all sides. The practice sometimes recommended of wrapping the shipping box in heavy paper, with a little excelsior between the box and the paper,

and no outside box for protection, is a dangerous one, and often leads to severe breakage. Any specimen that is worth determination is worth protection in transit.

If one or a small number of specimens is being shipped, they may be pinned into the corks of shell vials, one to each vial, and shipped in a box with sufficient packing. Vials containing alcoholics, or vials, gelatin capsules, or pill boxes containing unmounted insects may be shipped in the same way and with similar precautions concerning packing between the insect containers and the outer box.

## CLASSIFICATION OF THE DIPTERA

The order Diptera includes not only the familiar flies of the housefly and bluebottle type, but also the mosquitoes, midges, gnats, horseflies, and a number of others, many of which are not familiar to the lay person. There is considerable disagreement as to their classification in respect both to families and to categories above the family level. There is no need to be concerned, for the purposes of this work, with much other than the family classification; and as to that, a rather conservative system is here used. Most of the flies involved in myiasis belong to the muscoids or housefly type (in a broad sense). The term "muscoid" is used considerably in the text, and it will be necessary to keep in mind the two divisions of the Muscoidea—the Acalypteratae, in which the squamae or calypteres as a rule are small, and the Calypteratae, in which the calypteres are well developed. The families of Acalypteratae discussed here are the Sepsidae, Piophilidae, Tylidae, Drosophilidae, and Ephydridae; the families of Calypteratae are the Oestridae, Cuterebridae, Gasterophilidae, Hypodermatidae, Larvaevoridae, Muscidae (including the Anthomyiidae), Calliphoridae, and Sarcophagidae. The families of the Calypteratae, with the exception of the Larvaevoridae, are of major importance.

The keys that follow were constructed for the purpose of aiding in the identification of the myiasis-producing flies. They cannot, therefore, be relied upon in the case of genera other than the myiasis-producing ones of families treated in this work. An attempt has been made to use phylogenetically significant characters whenever feasible, but the main purpose of presenting the keys has been utilitarian.

## KEYS TO FAMILIES OF DIPTERA

ADULTS

1. Antenna consisting of more than 3 segments; if apparently only 3, the third is compound, formed of several annuli, or with an annulated apical style ..... 2
   Antenna apparently 3 segmented, the third segment bearing a dorsally placed arista ..... 6
2. Small, mothlike flies, the wings short and broad, long-haired, pointed (fig. 84, *A*), and folded rooflike over the body when at rest; discal cell incomplete; ocelli absent ..... PSYCHODIDAE
   Larger flies, the wings moderately long, not long-haired or pointed; discal cell well developed ..... 3
3. Mesonotum with a V-shaped suture, the apex of which is directed toward the scutellum; ocelli absent; usually medium to rather large slender flies, with very long legs ..... TIPULIDAE
   Mesonotum without a V-shaped suture; ocelli present ..... 4
4. Antenna about as long as the thorax, 12 to 16 segmented, the segments distinct; posterior cells all open ..... SYLVICOLIDAE

Antenna shorter than the thorax, with not more than 10 segments, those beyond the second fused to form an apparently annulated third segment or a third segment with an apical style ..... 5

5. Body without distinct bristles or bristly hairs; wing veins tending to crowd toward the costal margin with the result that the discal cell is usually small and located on the anterior half of the wing (fig. 88) ..... STRATIOMYIDAE

Body with bristles, at least on the legs; wing venation normal, the discal cell relatively large and located on the posterior half of the wing (fig. 3); vertex, from anterior view, not concave; 5 posterior cells ..... THEREVIDAE

6. Wing with a spurious vein, that is, a veinlike fold in the membrane between the radius and media and transversing cross vein *r-m* (fig. 91) ..... SYRPHIDAE

Wing without such a spurious vein ..... 7

7. Mouth parts vestigial (cf. fig. 61) ..... 8

Mouth parts well developed ..... 11

8. Postscutellum distinctly formed; squamae large; apical cell greatly narrowed or closed at its apex ..... 9

Postscutellum undeveloped ..... 10

9. Apical cell closed and petiolate (fig. 62) ..... OESTRIDAE

Apical cell open ..... HYPODERMATIDAE

10. Squamae large; apical cell greatly narrowed at its apex (fig. 47) ..... CUTEREBRIDAE

Squamae small; apical cell gradually broadening to the wing margin (fig. 45) ..... GASTEROPHILIDAE

11. Wing with the anterior veins strong and the others oblique and weak (fig. 97) ..... PHORIDAE

Wing of the normal muscoid type, without unusual venation (cf. figs. 4 and 71) ..... 12

12. Second antennal segment with a longitudinal suture extending along its upper outer edge (cf. fig. 1); squamae usually large; postalar callus distinct ..... 13

Second antennal segment without a longitudinal suture; squamae usually small; postalar callus not differentiated ..... 16

13. Postscutellum well developed ..... LARVAEVORIDAE

Postscutellum undeveloped ..... 14

14. Hypopleural bristles present; apical cell greatly narrowed toward its apex (fig. 4) ..... 15

Hypopleural bristles absent; apical cell sometimes greatly narrowed toward its apex (fig. 82) but often broadly open (figs. 71 and 78) ..... MUSCIDAE

15. Two notopleural bristles present; body, in myiasis-producing species, either largely metallic blue, purple, or green, or largely testaceous ..... CALLIPHORIDAE

Three or more notopleural bristles present; body in myiasis-producing species grayish, with either pollinose spots or a tesselated pattern on the abdomen ..... SARCOPHAGIDAE

16. Subcosta distinctly differentiated from vein $r_1$ and ending independently in the costa (fig. 96) ..... 17

Subcosta absent or only partly developed, not reaching the costa ..... 19

17. Metathoracic spiracle with 1 to several hairs, visible only under high magnification, on its border; palpi vestigial ..... SEPSIDAE

Metathoracic spiracle with only ordinary soft pubescence; palpi well developed ..... 18

18. Vibrissae present; legs short ..... PIOPHILIDAE

Vibrissae absent; legs long and stiltlike ..... TYLIDAE

19. Arista plumose (in species considered here); vibrissae present; oral opening of moderate size. Small yellowish flies with a prominent facial carina and with black abdominal markings ..... DROSOPHILIDAE

Arista bare (in species considered here); vibrissae absent, but the face may be bristly; oral opening unusually large and gaping ..... EPHYDRIDAE

MATURE LARVAE

1. Head distinct and sclerotized dorsally, though sometimes retractile into the prothorax; antennae distinctly developed and situated on a sclerotized plate; no free cephalopharyngeal skeleton; mandibles broad ..... 2

Head poorly developed, appearing externally as an unsclerotized cephalic segment; antennae usually absent, when present poorly developed and situated on an unsclerotized surface; free cephalopharyngeal skeleton present; mandibles replaced functionally by mouth hooks ..... 6

2. Head complete, not retractible into the prothorax and separated from it by deep incisions (figs. 85 and 87); mandibles opposed, moving horizontally ..... 3

Head incomplete, that is, retractile into the prothorax (fig. 89) ..... 4

3. Each thoracic and abdominal segment divided into 2 or 3 annuli, at least some of which bear transverse sclerotized bands dorsally; the apical segment modified into a sclerotized air tube (fig. 85) ..... PSYCHODIDAE

The thoracic and abdominal segments not divided into annuli, but each abdominal segment with an anterior constriction; no sclerotized air tube; apical segment usually with 5 short processes surrounding the spiracle ..... SYLVICOLIDAE

4. Mandibles opposed, moving horizontally; body cylindrical, with several prominent fingerlike processes around the posterior spiracles ..... TIPULIDAE

Mandibles moving vertically; body not as above ..... 5

5. Body flattened, its surface finely shagreened; lateral abdominal spiracles present (fig. 89) ..... STRATIOMYIDAE

Body cylindrical, not shagreened; lateral abdominal spiracles absent; last abdominal segment ending in 2 points vertically ..... THEREVIDAE

6. Smooth maggots (figs. 14 and 83), the body conically tapering, narrow in front and broad and truncated behind, without prominent tubercles or processes on any segment but the last; posterior spiracles flush with the posterior face of the anal segment or sunken into a concavity or depression ..... 7

Not such larvae; that is, either grublike, or with lateral or dorsal tubercular or spinous processes on the segments, or with the posterior spiracles at the end of 2 processes or of a respiratory tube ..... 9

7. Posterior spiracles deeply sunken in a rounded concavity; inner slits directed away from the median line below (fig. 14, *B*) ..... SARCOPHAGIDAE

Posterior spiracles flush with the posterior face of the anal segment; or, if they are sunken in a shallow slitlike concavity, the inner slits are directed toward the median line ventrally ..... 8

8. Slits of posterior spiracles either sinuous or short and radially arranged (cf. figs. 65 and 68) ..... MUSCIDAE (in part)

Slits of posterior spiracles long and slender, more nearly parallel to one another (cf. figs. 33 and 35) ..... CALLIPHORIDAE (in part)

9. Larvae grublike ..... 10

Larvae not grublike ..... 15

10. Each posterior spiracle with 3 distinct slits ..... 11

Each posterior spiracle with numerous small openings, but without well-defined slits (cf. fig. 55) ..... 13

11. Either nude, wrinkled larvae with the posterior spiracles separated by several times the diameter of each (*Auchmeromyia*, fig. 37) or the slits sinuous (*Cordylobia*, *Stasisia*, fig. 40) ..... CALLIPHORIDAE (in part)

Spine-bearing larvae without sinuous slits in the posterior spiracle ..... 12

12. Pear-shaped species (fig. 50); spiracular slits straight and elongated, deeply sunk into a concavity (*Dermatobia*) ..... CUTEREBRIDAE (in part)

Ovate species (fig. 44); spiracular slits bent at the middle and in at most a shallow concavity ..... GASTEROPHILIDAE

13. Mouth hooks rudimentary ..... HYPODERMATIDAE

Mouth hooks well developed ..... 14

14. Body with spines weak and located on the ventral surface only or on the anterior margin of each segment dorsally ..... OESTRIDAE

Body with spines or spinous plates stronger and more evenly distributed ..... CUTEREBRIDAE

15. Body with tubercular, fleshy, or spinous processes dorsally and laterally on the segments ..... 16

Body without such processes, at most with prolegs ..... 18

16. More or less cylindrical larvae with short or moderately short, unbranched, lateral and dorsal tubercles on the segments ..... 17

Flattened larvae with long filiform processes which are branched at least basally and may appear feathery, on the dorsum and sides of the segments; posterior spiracles borne on stalks, each stalk with 4 lobes on which are found the 3 slits and the button (*Fannia*, figs. 70 and 72) ..... MUSCIDAE (in part)

17. Small, dirty white, slightly flattened larvae, measuring up to 4 mm., with short processes on the dorsal and lateral surfaces; posterior spiracles on brown, sclerotized tubercles, each with a narrow opening (fig. 98) ..... PHORIDAE

Larger, more nearly cylindrical larvae, with longer, pointed fleshy processes laterally and dorsally; posterior spiracles in a cleft on the posterior face of the anal segment and consisting of flattened plates perforated by 3 slits (*Chrysomya*, in part, fig. 32) ..... CALLIPHORIDAE (in part)

18. Posterior spiracles at the end of a long, retractile respiratory tube which, when extended, is longer than the length of the body proper; rat-tailed maggots (fig. 90) ..... SYRPHIDAE (in part)

Posterior spiracles on short tubercles or a short respiratory process which is much shorter than the body length ..... 19

19. Robust larvae, with the body transversely wrinkled, broad behind and tapering anteriorly; posterior spiracles small and situated close together at the apex of a short respiratory tube (*Syrphus*) ..... SYRPHIDAE (in part)

Body form not as above, not strongly wrinkled transversely; posterior spiracles on separate tubercles or on a forked respiratory process ..... 20

20. Posterior spiracles at the end of the branches of a forked respiratory process; moderately stout larvae (figs. 92 and 93) ..... 21

Posterior spiracles situated at the apices of short cones; very slender larvae (fig. 95) ..... 22

21. Last 2 thoracic segments and first 6 abdominal segments each with a spinose ambulatory protuberance, or proleg, on each side (fig. 92) ..... EPHYDRIDAE

Thoracic and abdominal segments without prolegs ..... DROSOPHILIDAE

22. Anal segment with a pair of fingerlike ventrolateral processes; mature larvae do not skip ..... SEPSIDAE

Anal segment with a pair of ventrolateral processes which are tapered and point slightly upward; mature larvae move in a skipping fashion ..... PIOPHILIDAE

## The Family SARCOPHAGIDAE

The family Sarcophagidae includes a wide variety of biotic types; among these are the familiar medium-sized grayish flies, with tessellated abdomens, that are frequently found around carcasses of dead animals. Many species, however, do not breed in carrion; some are excrement breeders, some parasitize insects, snails, and other invertebrates, and some breed in decaying vegetable matter. The family contains about a thousand described species and without doubt many more that are yet to be described. It occurs throughout the world, except in the polar regions; its members are most abundant in the Holarctic Region but are also well represented in the tropics.

The family has been treated under different names by certain authors, although the usage employed here is the usual one. Curran (*29*) unites this family with the Calliphoridae under the name Metopiidae, while Townsend (*153, pt. VI, p. 64*) uses the name Stephanostomatidae. Some species were formerly considered as belonging to the Larvaevoridae (Tachinidae).

In general the family contains flies of medium size, usually gray with the abdomen frequently marked with checkerboard patterns which change with the light incidence. The eyes are broadly separated in both sexes, although usually the front is somewhat narrower in the male. The mouth parts are well developed. Hypopleural and pteropleural bristles are present. The postscutellum is never developed; its absence will readily distinguish doubtful cases from the Larvaevoridae. The wing has vein $m_1$ bent strongly forward and ending before the apex of the wing, although the apical cell is in most cases open.

In all species treated in this work, the arista is plumose above and below for more than half its length, though not to the apex (except *Wohlfahrtia*, in which it is only short-pubescent); the eyes are bare; the mouth parts are well developed, but the proboscis is never exceptionally long as it is in some of the Larvaevoridae; the face is concave in profile and is never strongly receding, its length at the vibrissae being much more than half, often fully, that at the antennae; the epistoma is warped forward; the vibrissae are well differentiated; the parafacials are hairy; and the intermediate abdominal segments are without discal bristles.

## KEY TO GENERA

The following key will be useful in helping to distinguish adults of the three genera treated in this publication; it must, however, be kept in mind that there are many others in this family.

1. Arista short-pubescent (fig. 8, *B*); abdomen with constant markings which are independent of the light incidence
*Wohlfahrtia* Brauer and Bergenstamm

Arista short- to long-plumose; abdomen with changeable pollinose patterns ..... 2

2. Arista short-plumose (fig. 8, *C*); scutellum with a mat of dense pile on each side toward the base, below the level of the lateral bristles. Some other genera not considered in this work (e. g., *Agria*) have the short-plumose arista but lack the characteristic lateral hair patches
*Titanogrypha* Townsend

Arista long-plumose (fig. 8, *A*); scutellum without mats of dense pile as described above ..... *Sarcophaga* Meigen

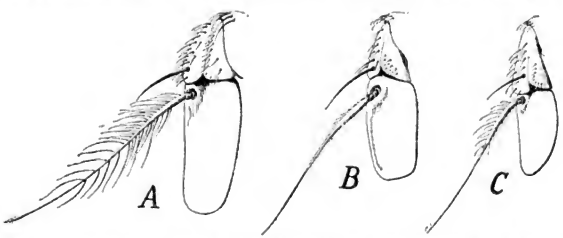


FIGURE 8.—Antennae: *A*, *Sarcophaga bullata*; *B*, *Wohlfahrtia magnifica*; *C*, *Titanogrypha ulata*.

### The Genus WOHLFAHRTIA Brauer and Bergenstamm

This genus includes medium-sized Sarcophagidae, usually 10–15 mm. in length. The abdomen lacks the tessellated or changing checkerboard appearance of the more typical Sarcophagidae. On the contrary, except in one Chinese species, it is gray, with characteristic constant black spots in three longitudinal series; these spots may be small and confined to the apical halves of the segments, or, as in *W. vigil*, they may fuse strongly, so that the abdomen may appear mainly black. The larger size, coupled with the characteristic abdominal markings, will in general serve to distinguish this genus from other members of the family.

The arista is very short-haired and may appear bare under lower magnifications; the eyes are broadly separated in both sexes, more so in the female than in the male; vein $r_1$ is bare.

A taxonomic treatment of the species of the world has been made by Salem (*129*). Of the 17 known, 3 are of medical importance; the others, as far as known, being scavengers or parasitic on insects.

**Larva.**—Too little is known of the immature stages of the Sarcophagidae to make possible any positive statement of generic characters. In the known species of *Wohlfahrtia*, the branches of the anterior spiracles are few in number, usually 5 to 9, rarely 10, and spread out fanlike; most species of *Sarcophaga* have the branches more numerous, but this is not universally true. The more robust form of the *Wohlfahrtia* larva will aid in distinguishing it from *Sarcophaga*.

As in *Sarcophaga* larvae, the anterior end tapers strongly from the middle toward the front; however, the general form is much more robust. The posterior end is truncated, the spiracles being located in a pronounced depression or posterior cavity; above and below this cavity are 12 tubercles, 3 on each side above and the same below; these tubercles are less strongly developed than in *Sarcophaga* (fig. 9). Below, on the posterior face of the last apparent segment, is an enlarged portion known as the anal area, which, as in *Sarcophaga*, terminates on each side in a prominent tubercle. Prominent spinous areas are present at either the anterior or posterior margins of the segments, or both.

Extensive descriptions and figures of larvae in the various stages are given by Portchinsky (*118*) for *Wohlfahrtia magnifica* and by Walker (*158*) for *W. vigil*.

**Pathogenesis.**—Two entirely different types of myiasis are produced by members of this genus. In Eurasia, *W. magnifica* produces a serious form of traumatic and rhinal myiasis, whereas in the northern United States and Canada *W. vigil* and *W. opaca* produce a furuncular subcutaneous type in children.

## KEY TO SPECIES

1. Abdomen chiefly shining black, with isolated pollinose areas in 4 longitudinal rows, 2 down the middle of the segments and 1 on each side ..... *vigil* (Walker)
   Abdomen chiefly pollinose, with 3 longitudinal rows of shining black spots ..... 2
2. The central spot on the third segment large and usually triangular, prolonged forward to touch, or nearly so, the base of the central one on the second segment ..... 3
   The central spot on the third segment smaller; in the female it is limited to the apical part of the segment; in the male it is flasklike, the body being small and the neck prolonged forward ..... *nuba* (Wiedemann)
3. Second antennal segment orange-colored and approximately equal in length to the third; palpi orange ..... *opaca* (Coquillett)
   Second antennal segment black and distinctly shorter than the third; palpi black ..... *magnifica* (Schiner)

## WOHLFAHRTIA MAGNIFICA (Schiner)

(Fig. 10)

SYNONYMS.—*Sarcophila magnifica* Schiner; *Sarcophaga magnifica* (Schiner); *Sarcophila wohlfahrti* Portchinsky.

RECOGNITION CHARACTERS.—Adult: The antennae are black, at most the apex of the second segment being yellowish or reddish; the third segment is half again to twice as long as the second. The palpi are black. There are about four

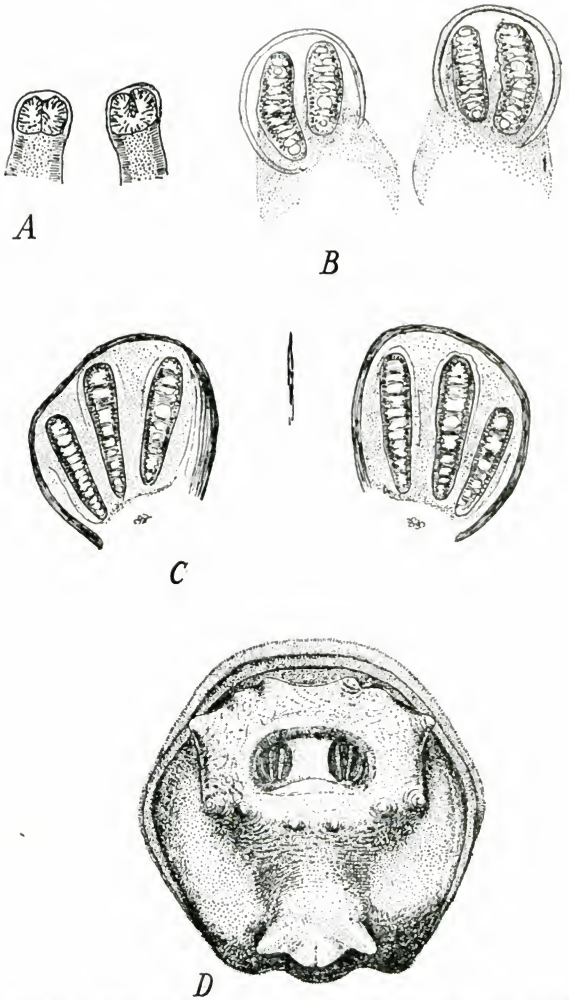


FIGURE 9.—*Wohlfahrtia vigil*, details of larvae; posterior spiracles of *A*, first-stage; *B*, second-stage; *C*, third-stage larva; *D*, posterior view of last segment of mature larva. (After Walker (*158*, p. 173).)

pairs of presutural acrosticals. The lateral abdominal spots are rounded and well defined; the median spots on the first three segments each reach the base of the respective segment, thereby forming a connected band; the fourth segment has three small spots at the apex. Larva: The spinous areas are much as in *Wohlfahrtia vigil;* the spines, however, are coarser. The anterior spiracle has five or six papillae.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Spain, France, Italy, Germany, Poland, Hungary, Yugoslavia, Bulgaria, European Russia (central and southern), Morocco, Algeria, Libia, Egypt, Palestine, Iraq, Iran, Asiatic Russia, south of Perm, Manchuria, Mongolia, China. Portchinsky states that this species is absent from England, Netherlands, Finland, Denmark, Scandinavia, and northern Russia. Ethiopian Region: Natal.

**Biology and Pathogenesis.**—This species is a scourge in the steppes of southeastern European and southern Asiatic Russia, in Asia Minor, and in North Africa, where people lead a nomadic life which exposes them to the attacks of the parasite. The adult flies rarely enter houses, but frequent fields, orchards, and other open places. The females are flower feeders until they become sexually mature. They like warmth and light, and so do not fly in the early morning or late evening, or in dark, gloomy weather.

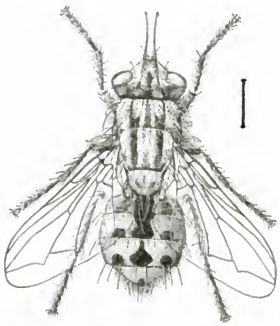

FIGURE 10.—*Wohlfahrtia magnifica*, adult female.

The female will larviposit in sores, cuts, wounds, and body openings, the nose, eyes, and ears being the most frequently attacked. Each female, according to Portchinsky, carries 124 to 168 larvae; in one case of ophthalmomyiasis in Spain 70 larvae, which were submitted for identification, were said to represent about half the number taken from one eye. The larvae burrow into the tissue and grow rapidly; they molt on the second or third day; after another 3 or 4 days they have completed the third larval stage and are ready to crawl out of the wound to pupate.

The larvae are extremely hardy. Specimens kept in 95-percent alcohol for an hour have been known to pupate and emerge as adults. Larvae can survive for considerable lengths of time in pure hydrochloric acid, turpentine, or solutions of corrosive sublimate, boric acid, or carbolic acid; however, they perish in sulfuric ether or in chloroform water (0.2 in 100).

In areas infested by this fly it is dangerous to sleep out of doors between 10 a. m. and 4 p. m. in the summer months. Because of the large size, rapid growth, and often considerable numbers of the larvae, the damage they do is often great unless the disease is treated at once. In cases of auditory myiasis the larvae within the auditory meatus usually penetrate the walls, and sometimes enter the cartilage. Deafness may result either from damage to the meatus or from the blocking of it as a result of inflammatory growths. Destruction of tissue in the nasal regions is often severe and has been known to cause death in human beings. Myiasis in the eyeball may result in the complete

destruction of that organ. The maggots never penetrate the digestive organs and are not known to cause myiasis of the digestive tract; however, they may penetrate deeply into thick muscles and damage them severely.

**Status as a Parasite.**—From all indications this is a specific myiasis producer. Records by early authors indicating that this species is a scavenger are, according to Portchinsky, probably due to misidentification.

**Literature.**—An extensive treatment of this fly and of its history, biology, pathogenic aspects, and life history, illustrated, is given by Portchinsky (*118*), and various cases of myiasis involving *W. magnifica* are discussed by Salem (*127*).

### WOHLFAHRTIA VIGIL (Walker)

(Fig. 11)

SYNONYM.—*Paraphyto chittendeni* Coquillett.

RECOGNITION CHARACTERS.—Adult: This species differs from all other known members of the genus in that the usual black abdominal spots are large and confluent, the abdomen consequently appearing black with gray pollinose spots. Larva: This is similar to that of *W. magnifica*, with a similar distribution of spinous areas; the spines, however, are not so coarse. The anterior spiracle has nine or ten papillae, and the peritreme of the posterior spiracles is thinner (fig. 9).

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alaska, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, New York, Pennsylvania, Ohio, Michigan, Minnesota, Wisconsin, Iowa, North Dakota, South Dakota, and Idaho. Most cases of myiasis have been reported from Minnesota, the adjoining Dakotas, and southern Ontario.

**Biology and Pathogenesis.**—Development is rapid, the life cycle being completed in 30 to 36 days under conditions in southeastern Canada. Larviposition takes place from 11 to 17 days after the emergence of the adult, the larvae mature in 7 to 9 days, and the pupal period lasts 10 to 12 days.

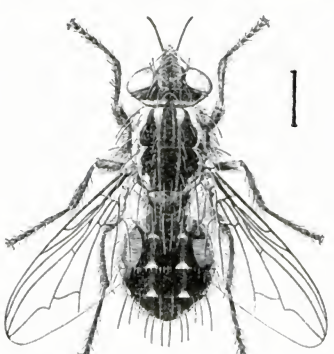

FIGURE 11.—*Wohlfahrtia vigil*, adult female.

The human cases recorded are babies under 5 months of age who have slept out of doors unprotected by nets or screens. The exception recorded by Felt (*39, p. 175*) of the case of a maggot, supposed to be this species, taken from a small cyst in the conjunctiva of a man was a misidentification.

Larvae are deposited in groups on exposed parts of the body; after larviposition, they separate and wander about, sometimes for considerable distances, before penetrating the skin. Unlike *W. magnifica*, the larvae enter the unbroken skin, but are capable of doing so only if the skin is tender. The female fly, in her larviposition response,

seems, with few exceptions, to be attracted only to the young of the species, whether human or animal. The usual areas of infestation are the neck, chest, shoulders, and arms, although sometimes the eyelids, cheeks, palms, and navel are attacked.

Even an attempted, unsuccessful penetration by the larvae may cause noticeable irritation of the skin. When the larva has become established, small, abscesslike lesions, each measuring 6-20 mm. in diameter, appear. Closer examination will reveal, however, that the apparent pus is in reality the posterior end of the larva, which is constantly being extruded and withdrawn during the feeding operations. The lesions are suggestive of impetigo, and some cases have been incorrectly diagnosed as that malady. In most cases studied by Walker and Ford in Canada, 12 to 14 lessions were present, although the number may reach as high as 40. Usually each larva penetrates the skin independently, although as many as 5 larvae have been taken from a single lesion.

This disease may be diagnosed by the charateristic lesions, a slight elevation in temperature, irritability, dehydration, and loss of appetite. Secondary bacterial infection may occur. No fatal cases are known to have occurred in man, though such are frequent in young mink on fur farms.

Since the lesions are usually open, the larvae may be removed without an incision by gently applying pressure; antiseptic precautions should, of course, be employed. Prevention consists in not permitting small children to sleep out of doors in infested areas during the summer months. Screening may not always afford adequate protection, since larvae may be dropped through screens or deposited where they may be able to crawl into the screened area. Cleanliness is no safeguard against infestation, since these flies, unlike most members of this and related families, are not attracted by fetid odors.

**Status as a Parasite.**—In spite of the statement of Patton and the earlier opinions of Walker to the contrary, this is probably a specific myiasis producer. Patton's contention that the parasitic habit was abnormal to this species was based on the small size of the spines of the larval skin, these being usually better developed in parasites than in saprophytes. However, Walker (*157*) seems to have reversed his early opinion on the grounds that the habit of penetrating healthy skin is not normal for a carrion feeder; the larvae have never been recorded from carrion, except in laboratory experiments; and gravid females, according to laboratory experiments, are attracted, not to carrion, but to living young animals, and will not larviposit on carrion except as a very last resort.

In addition to man, the young of domestic and wild animals, especially mink, are parasitized.

**Literature.**—For immature stages, Walker (*158*); for habits, Ford (*40*); for pathogenesis, Walker (*157*) and Ford (*40*); and for a detailed account of parasitism in man and animals, Kingscote (*69*).

### WOHLFAHRTIA OPACA (Coquillett)

SYNONYMS.—*Paraphyto opaca* Coquillett; *Wohlfahrtia meigeni* of American authors, not of Schiner.

RECOGNITION CHARACTERS.—Adult: The second antennal segment is orange in color and subequal to the third in length; the palpi are likewise orange. There are no presutural acrosticals. The abdomen is colored as in *W. magnifica*, except

that, in some cases, the median spots may not reach the bases of the segments. Larva: No description has been published; the larva is presumably as in *W. rigil*.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alberta, British Columbia, South Dakota, Montana, Idaho, Wyoming, Colorado, Utah, New Mexico, Arizona, Washington, Oregon, California.

**Biology and Pathogenesis.**—The clinical data are the same as those for *W. rigil*. Some cases of human myiasis are on record, and the young of dogs, foxes, and mink have been attacked.

No satisfactory distinctions in external characters have been made between this species and the European *W. meigeni* (Schiner), although biologically they are quite different, the European species being strictly saprophytic.

### WOHLFAHRTIA NUBA (Wiedemann)

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Libia, Egypt, southern Arabia, Uzbek (Bukhara). Ethiopian Region: Senegal (Dakar), Anglo-Egyptian Sudan (Khartoum), Ethiopia, Socotra.

**Pathogenesis.**—This species frequently infests wounds of animals, particularly camels, and of nomads belonging to tribes associated with camels in northern Africa. Indications are, however, that it feeds on diseased tissue only. A small number of larvae were reported by Roubaud (*126*) to have been taken from a dog in a case that ended fatally, but the maggots were probably not the cause of death. This species has been used in maggot wound therapy.

## The Genus TITANOGRYPHA Townsend

The species of this genus resemble a small *Sarcophaga*, but may easily be distinguished by the presence of a mat of short, dense hairs on each side of the scutellum below the level of the lateral bristles (fig. 12, *B*). The antennal arista is short-plumose about halfway to the tip (fig. 8, *C*); vein $r_1$ is setulose about halfway to the apex, and

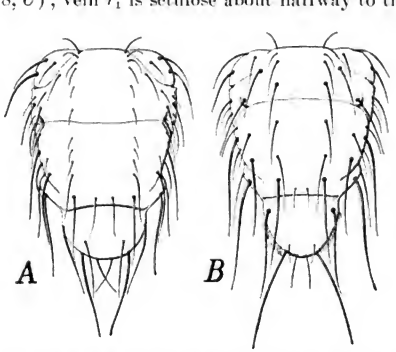


FIGURE 12.—Outline drawing of thorax: *A*, *Sarcophaga bullata*; *B*, *Titanogrypha ulula*, to show mesonotal chaetotaxy.

vein $r_{4+5}$ is setulose to cross vein *r-m*, cell $r_5$ is closed in the margin or narrowly open, and a strong costal spine is present (fig. 13); and the abdomen is terete, with strong erect marginal bristles on segments 2 to 4 and with black terminalia.

### TITANOGRYPHA ALATA (Aldrich)

SYNONYM.—*Sarcophaga melampyga* var. *alata* Aldrich.

RECOGNITION CHARACTERS.—Adult: This species is distinguished from the only other North American species, *Titanogrypha melampyga* (Aldrich), by the structure of the male genitalia. Larva: Only the first-stage larvae have been described. The third to twelfth segments bear circlets of microspines on their anterior margins, those of the third and fourth segments being widest and most complete; the mouth parts are unusually strong and large, the oral sclerite being especially large and elongated. The larva of *T. melampyga* is unknown.

GEOGRAPHICAL DISTRIBUTION.—Florida, southern Texas, and Cuba. The related *T. melampyga* occurs as far north as New Jersey and Indiana, and westward to Washington. Several other species have been described from the Neotropical Region.

**Pathogenesis.**—Townsend (*154; pt. 2, p. 176; pt. 5, p. 219;* and *pt. 12, p. 174*) says that this species occasionally infests wounds, open

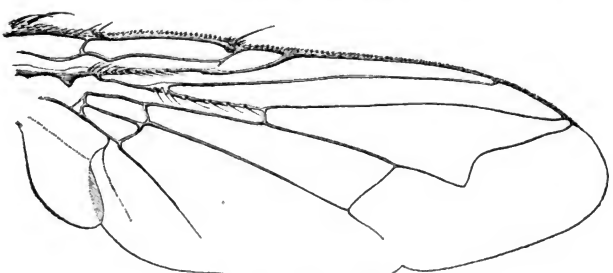

FIGURE 13.—*Titanogrypha alata*, wing.

sores, and diseased body openings of man and animals; he believes that the head skeleton of the maggot, with its powerful mechanism for tearing animal tissues, may indicate that it normally infests living tissues.

### The Genus SARCOPHAGA Meigen

This genus is undoubtedly a heterogeneous one. It is here maintained in its broad sense, not because, taxonomically, it should be so, but because attempts to divide it are as yet so far from being generally accepted that in such a work as this more confusion than order would result from the adoption of such a division. Some of the restricted generic uses more commonly found in the literature are indicated under the synonymies of the individual species.

In the sense here employed, *Sarcophaga* contains a large number of species of medium-sized gray or grayish flies, the abdomens of which are marked with light and dark pollinose spots in a checkerboard

pattern, the design of which appears to change with the light incidence. The arista is long-plumose above and below for more than half its length, but not to the apex; the parafacials are hairy or bristly; the vibrissae are well developed and close to the epistoma which is distinctly warped forward. The male lacks fronto-orbital bristles; the female in most cases has three on each side, two proclinate and one reclinate. There are three or more postsutural dorsocentrals, or, if only two are evident, they are on the posterior half of the region of the mesonotum behind the suture, the first two or more of the series being absent. Vein $m_1$ bends abruptly forward so that the first posterior cell is greatly narrowed but not closed; vein $cu_1$ always lacks setulae, although $r_1$ and $r_5$ may be either setulose or bare. The above characters are shared by most members of the genus (in the broad sense) and will serve to separate it from most other genera.

Specific determinations are difficult because of the large number of similarly appearing species; they often depend on male genitalia or secondary sexual characters of the male. Females therefore are frequently undeterminable specifically.

For a taxonomic treatment of the North American forms of *Sarcophaga*, Aldrich (*1*) will serve, although some species have been described since then and certain changes in names are necessary. Some of these changes have been indicated in a later paper by Aldrich (*2*). Rohdendorf (*124*) covers not only the Russian but to a large extent the Palaearctic species; the work is written in Russian, but the keys and descriptions of new species, as well as of some other material, are translated into German. Recently the species from other parts of the world have been treated by Senior-White, Aubertin, and Smart (*139 p. [208]–277*) for the Oriental Region (not merely India, as are most parts of this series). Hardy (*52*) for Australia, Lopes (*84*) for Hawaii, Bezzi (*15*) for the South Pacific islands, Patton and Wainwright (*110*) for the British Isles, Curran (*28a*) for the Ethiopian Region (in part), Hall (*47*) for Panama, Hall (*48*) for Patagonia and South Chile, Curran (*30*) for British Guiana, and Salem (*128*) for Egypt.

**Biology.**—As far as known, the species are ovoviviparous, the females giving birth usually to a limited number of large and relatively active larvae. Eggs are produced only under very unusual circumstances. Details of life histories vary considerably with different species and in different localities for the same species, according to published accounts, but the following statements seem to be typical. The larva is forced from the larvipositor of the parent usually head-first, and soon after emergence disappears into the food material. The number of larvae produced by a gravid female ranges on an average from 20 to 40, according to Knipling (*73*); some species will average higher, however, and one gravid female of an unknown species gave birth to 325 young. Development is rapid, the third instar usually appearing in 3 or 4 days, and the adult emerging, in most species, in about 2 weeks, although in some species the time required is much greater. Hibernation in temperate climates is in the pupal stage.

The fact that the larvae are produced alive and that their development is very rapid should make one cautious in blaming contaminated stools on cases of intestinal myiasis, since contamination can occur very easily. It is possible for 1-day-old stools to contain third-stage larvae. Knipling (*73*) records one case of a larva of *Sarcophaga stimulans* Walker reaching the third stage in 21 hours, pupating in less than

4 days, and emerging as an adult in 10¾ days. Patton (*101*) makes the surprising statement that, in his rearing experiments for Calliphoridae in India, *Sarcophaga* larvae ultimately reached meat kept in glass jars covered with glass lids, the edges of which had been carefully coated with vaseline.

**Larva.**—The larva (figs. 14 and 15) is of the usual muscoid type, the anterior end usually tapering strongly from the middle toward the front. The posterior end is truncate, the spiracles being located in a pronounced depression or posterior cavity; above and below this cavity are a number of tubercles, usually 3 on each side above and the same number below, to make a total of 12. The spiracular plates lack the button. Below, on the last apparent segment, is an enlarged portion, known as the anal area, which terminates on each side in a rather sharp tubercle.

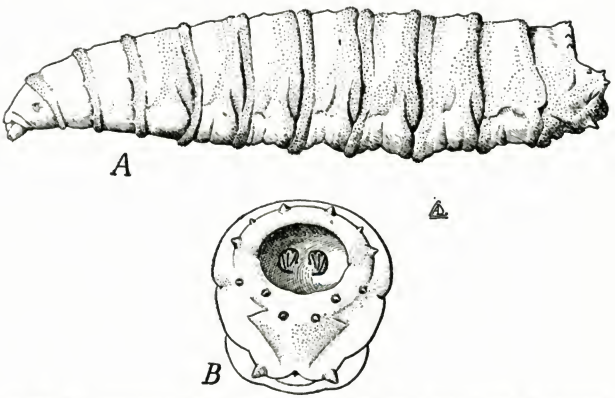


FIGURE 14.—*Sarcophaga crassipalpis*, mature larva: *A*, Lateral view; *B*, posterior view of last body segment.

No very satisfactory generic characters are known which will separate this genus from *Wohlfahrtia* in the immature stages. The form, however, is less robust in both larvae and pupae. The number of branches of the anterior spiracles, given by some workers as diagnostic, cannot be used, as it ranges from 4 to 20 or more.

Descriptions of 24 first-stage larvae are given by Knipling (*73*), and of 4 third-stage larvae and numerous puparia by Greene (*45*).

**Pathogenesis.**—The habits of different species of *Sarcophaga* vary greatly, only a relatively small number of them being injurious to human welfare. Many species parasitize grasshoppers, lepidopterous larvae, and other insects and invertebrates, and a great number breed in carrion. Rohdendorf (*124*) lists four classes of species of Sarcophagidae associated with man, which he designates as synanthropic species as follows: (1) Species that breed in the excrement of man and animals; (2) species that breed in decaying flesh; (3) species that

produce specific myiasis (represented in the European fauna by *Wohlfahrtia magnifica* alone); and (4) species that breed in various media, including decaying flesh and excrement and sometimes refuse of plant origin. Any of these four classes may contain myiasis-producing forms, although, of course, only the third class contains specific myiasis producers. Any species that occurs in human excrement may conceivably be involved in intestinal myiasis, provided it can survive the anaerobic conditions that exist in the human digestive tract, the peristalsis, and the action of the digestive juices. As to the necrophagous species, the transition from decaying flesh to neglected

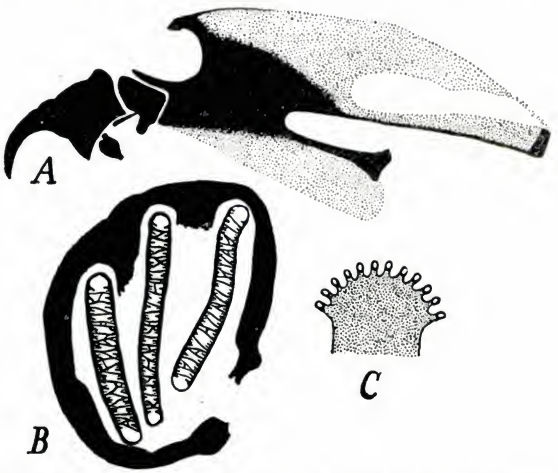


FIGURE 15.—*Sarcophaga crassipalpis*. Details of mature larva: *A*, Cephalopharyngeal skeleton; *B*, posterior spiracle; *C*, anterior spiracle. (After Smith (*144*).)

wounds or diseased body openings, and from there to healthy tissue, is not a difficult one, since it has been bridged many times by species of this and other genera of muscoid flies. According to Castellani and Chalmers (*25, p. 830*), *Sarcophaga* larvae are not uncommon in sores and ulcers in tropical regions.

Only scant etiological data concerning these flies have been published. Indeed, our knowledge of their biology in general is extremely inadequate. It is important to keep records carefully and get accurate determinations. If the literature on human and animal myiasis caused by species of this genus were not cluttered up with so many inaccuracies and conjectures, it would be possible to make much more positive statements on the subject.

**Taxonomy and use of the keys.**—Superficially many species of *Sarcophaga* look very much alike. Chaetotaxy is of some importance in determining the species, but the best identification marks are cer-

tain characters of the male. Since the keys given here are based partly on male characters, they can be used for the females only with great limitations; and they are not altogether satisfactory even for the males. Final determinations must, in many cases, depend on an examination of the male terminalia. It must also be kept in mind that only a small part of this great genus is being treated in this work. Positive identifications in this genus require the specialist; it is hoped, however, that the discussion here will give some indication as to what the species in hand may be or, at least, what it is not.

## KEY TO NEW WORLD SPECIES (BASED LARGELY ON MALES)

1. Three postsutural dorsocentrals, more or less evenly spaced (cf. *Titanogrypha alata*, fig. 12, *B*). *Sarcophaga sarraceniae*, as well as many other species which are not known to have any connection with myiasis, will trace here; see also *S. lambens*, in which an occasional aberrant specimen may have the first postsutural dorsocentral poorly developed.
   Four or more postsutural dorsocentrals (fig. 12, *A*), of which all but the last two may be weak ..... 2
2. Flexor surface of hind femur in the male with strong spinelike bristles; male hypopygium large and robust (fig. 20) ..... *plinthopyga* Wiedemann
   Flexor surface of hind femur in the male with at most ordinary bristles ..... 3

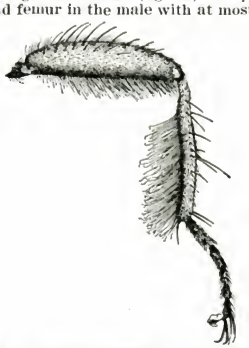

FIGURE 16.—*Sarcophaga bullata*, hind leg of male.

3. Hind tibia of the male with only ordinary hairs ..... 4
   Hind tibia of the male with long villous hairs forming at least a partial fringe (fig. 16) ..... 7
   Rows of frontals diverging below (fig. 18); epaulet black, though the basicostal scale is yellow ..... 5

FIGURE 17.—*Sarcophaga striata*, head of female, front view.

4. Rows of frontal bristles parallel, not diverging below (cf. *striata*, fig. 17); both epaulet and basicostal scale yellow
*Therminieri* (Robineau-Desvoidy)

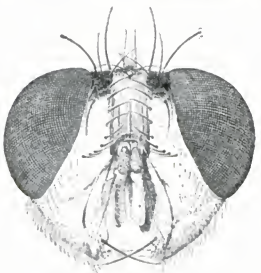

FIGURE 18.—*Sarcophaga haemorrhoidalis*, head of female, front view.

5. Male hypopygium of medium size; the posterior forceps tapering and slender apically ..... *placida* Aldrich
Male hypopygium small; the posterior forceps broad throughout and truncated apically ..... *lambens* Wiedemann
6. Prescutellar acrosticals absent or at most rudimentary
*haemorrhoidalis* (Fallén)
Prescutellar acrosticals well developed ..... 7
7. Middle tibiae with long villous hairs; larger species, usually 14 mm. or more in length, with considerable light golden pollen on the head and anterior parts of the thorax ..... *chrysostoma* Wiedemann
Middle tibiae without long villous hairs; species of medium size (usually 10–12 mm.) with gray or at most slightly yellow pollen. A very difficult complex of species runs to this point, and the distinctions made below must be considered rather unsatisfactory ..... 8
8. First genital segment black or blackish, at least on the apical half ..... 9
First genital segment yellow or red, at least on apical half ..... 11
9. Both genital segments entirely black ..... *harpax* Pandellé
*tuberosa* Pandellé
Genital segments in part prominently yellow or red ..... 10
10. Occiput with but a single row of black setulae behind the eyes
*crassipalpis* Macquart
Occiput with more than one row of black setulae ..... *barbata* Thomson
*exuberans* Pandellé
11. Third abdominal segment with median marginal bristles ..... *bullata* Parker
Third abdominal segment without median marginal bristles
*cooleyi* Parker

## KEY TO OLD WORLD SPECIES (BASED LARGELY ON MALES)

1. Three well-developed and evenly spaced postsutural dorsocentrals (cf. *Titanogrypha alata*, fig. 12, *B*) ..... 2
Four or more postsutural dorsocentrals, or at least the series distinctly spaced for four or more (fig. 12, *A*) ..... 3
2. Frontal bristles extending to the base of the antennae and not diverging below, except as they follow the margins of the frontalia (fig. 17)
*striata* (Fabricius)
Frontals extending below bases of the antennae and one or more bristles below the anterior points of the frontalia, and diverging below (cf. fig. 18) ..... *fertoni* Villeneuve
3. Hind tibiae fringed with long villous hairs (fig. 16) ..... 6
Hind tibiae with only ordinary short hairs ..... 4

4. Antennae salmon to red; the middle femur with a distinct comb of closely set bristles below ..... *ruficornis* (Fabricius)
Antennae black; middle femur with only widely spaced bristles ..... 5
5. Rows of frontals parallel, not diverging below (as in *striata*, fig. 17) ..... *Therminieri* (Robineau-Desvoidy)
Rows of frontals distinctly diverging below (as in *haemorrhoidalis*, fig. 18) ..... 6
6. Asiatic and Australasian species; genital segments usually brownish, sometimes black or reddish ..... *peregrina* Robineau-Desvoidy
South African species; genital segments red ..... *nodosa* Engel
7. Second genital segment black or blackish ..... 8
Second genital segment largely or wholly red or yellow ..... 11
8. Propleura abundantly haired ..... *froggatti* Taylor
Propleura bare ..... 9
9. Second abdominal segment with a pair of strong marginal bristles ..... *carnaria* (Linnaeus)
Second abdominal segment without marginal bristles ..... 10
10. Bristles of parafacials strong; setulae of cheeks entirely black ..... *tuberosa* Pandellé
*harpax* Pandellé
Bristles of parafacials weak; setulae of cheeks becoming pale posteriorly ..... *albiceps* Meigen
*misera* Walker
11. First genital segment black, with gray pollen ..... 12
First genital segment yellow or red ..... 13
12. Palpi black; second genital segment narrowly black apically ..... *crassipalpis* Macquart
Palpi yellow; genitalia entirely yellow ..... *hirtipes* Wiedemann
13. First genital segment with strong marginal hairs or bristles ..... 14
First genital segment without marginal bristles, the apical hairs of ordinary strength ..... 15
14. Prescutellar acrosticals strong ..... *barbata* Thomson
Prescutellar acrosticals weak or absent ..... *haemorrhoidalis* (Fallén)
15. Prescutellar acrosticals strong ..... *exuberans* Pandellé
Prescutellar acrosticals weak or absent ..... *beckeri* Villeneuve

### SARCOPHAGA L'HERMINIERI (Robineau-Desvoidy)

SYNONYMS.—*Sarcophaga communis* (Parker); *Sarcophaga pallinervis* Thomson; *Ravinia l'herminieri* (Robineau-Desvoidy); *Euravinia l'herminieri* (Robineau-Desvoidy).

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alaska, North Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Florida, Mississippi, Ohio, Michigan, Indiana, Illinois, Iowa, Missouri, North Dakota, South Dakota, Kansas, Arkansas, Louisiana, Texas, Montana, Idaho, Wyoming, Colorado, Utah, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico, Yucatan, Guatemala, Bermuda, Ecuador, Bolivia, Argentina. Australian Region: Hawaiian Islands.

**Pathogenesis.**—This species has been recorded from three cases of supposed intestinal myiasis in Texas. It breeds in excrement, including that of man, and the above-mentioned records were probably based on material received from subsequently contaminated stools.

### SARCOPHAGA SARRACENIAE Riley

**Pathogenesis.**—One case of supposed intestinal myiasis is on record, but the known food habits of this insect suggest that this record was based on a misidentification. The species was commonly misidentified in the literature prior to 1916.

## SARCOPHAGA HAEMORRHOIDALIS (Fallén)

The Red-tailed Flesh Fly
(Fig. 19)

SYNONYMY.—*Stephanostoma stephanostoma* (Lenz) of Townsend's Manual. Numerous specific names, including *Sarcophaga aurua* Rondani and *S. georgiana* Wiedemann, have been used for this species, and it has been placed at one time or another in several genera, including *Musca* (by Fallén), *Bercaea*, *Pierretia*, and *Coprosarcophaga* (Rohdendorf).

RECOGNITION CHARACTERS.—Adult: The frontal bristles extend below the base of the antennae and the rows are divergent; there are only two well-developed postsutural dorsocentrals situated close to the scutellum, although there may be three or four additional weak ones anterior to these in the series; there are no anterior or posterior acrosticals, or at most a very weak pair just in front of the scutellum; median marginals are lacking on the first two abdominal segments. The male hypopygium is reddish yellow, although its first segment is more or less blackened posteriorly; the hind tibia of the male is fringed with long black hairs. Vein $r_1$ is bare; $r_{4+5}$ has a few setulae at its base. Length 10–14 mm. Larva: The immature stages in this genus are too poorly known to permit the formulation of any diagnostic characters.

GEOGRAPHIC DISTRIBUTION.—Nearctic Region: Quebec, Ontario, Alberta, British Columbia, New Hampshire, Vermont, Massachusetts, Connecticut, New

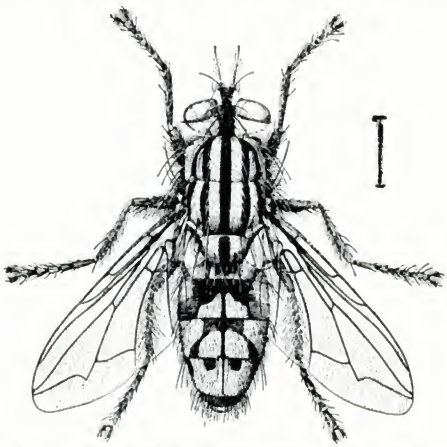

FIGURE 19.—*Sarcophaga haemorrhoidalis*, adult male.

York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, Georgia, Florida, Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Kansas, Oklahoma, Texas, Montana, Wyoming, Colorado, Utah, Arizona, Oregon, California. Neotropical Region: Honduras, San Salvador, Brazil, Argentina. Palaearctic Region: Ireland, England, Portugal, Spain, France, Netherlands, Italy, Corsica, Sardinia, Sweden, Denmark, Germany, Austria, Hungary, Yugoslavia, Rumania, Bulgaria, Greece, European Russia (south and west), Georgia (Abkhasia, Adzharia), Azerbaijan, Armenia, Azores, Canary Islands, Madeira, Morocco, Algeria, Tunisia, Libia, Egypt, Turkey, Dodecanese, Palestine, Arabia, Iraq, Iran, central Asiatic Russia, Turkmen, China (Peiping), northern India (Himalayas); not known to occur in northeastern European Russia, Siberia, or the East Coast Province of Asiatic Russia (according to Rohdendorf). Ethiopian Region: Li-

beria, Gold Coast, Nigeria, Cameroun, Anglo-Egyptian Sudan, Eritrea, Italian Somaliland, Socotra, East Africa, Belgian Congo, Angola, Uganda, Kenya, Tanganyika, Nyasaland, Southern Rhodesia, Natal, South Africa, Seychelles Islands, Mauritius, Admirantes Islands, Cargados Islands, Rodriguez Island. Australian Region: Introduced into New South Wales and Hawaii. Almost world-wide; apparently absent from the Oriental and much of the Australian Regions, and from the cooler parts of the world; rare in England and Denmark.

**Biology and Pathogenesis.**—Larvae are deposited on carrion, excrement, tainted meats, and other suitable breeding media. The duration of the immature stages varies considerably according to climate and locality. The larvae are usually scavengers, although they may become facultative parasites either in wounds or in the digestive tracts of mammals.

Occasionally the maggots of this fly invade wounds or diseased body openings, and pass from diseased to healthy tissue. The larvae are voracious, and upon invasion may produce deep and serious lesions. Onorato (*96*) records two cases of wound myiasis in Tripolitania, in one of which the larvae had entered healthy tissue and caused considerable pain. In a third case, in a middle-aged woman, entrance had been made through a carcinoma of the uterus, thereby further damaging that organ and causing abdominal pains, bloody discharges, and difficulties of urination; 132 larvae were removed, some of which were detected only through the use of the cystoscope. Kingscot[t]e (*69, p. 63*) reports a secondary infestation by this species of a lesion in a mink made by *Wohlfahrtia vigil*, from which 75 larvae were taken. In Mauritius this species is said to be responsible for a distinct, though small, percentage of the cases of wound myiasis in cattle.

There is considerable evidence to show that at least most of the authentic cases of gastrointestinal infestation involving *Sarcophaga* are due to this species. Larvae are presumably ingested with contaminated food. A detailed account of three cases—a mother and two children—with repeated attacks occurring over a period of 6 years, is given by Haseman (*56*). Contamination probably came from cold foods that had been left exposed to the air during the summer months. The reported symptoms consisted, first, of the sensation of rolling movements in the region of the base of the stomach or transverse colon, probably a result of movements of masses of the larvae; this was followed by griping pains in the abdomen, some fever, sometimes nausea, and, in the case of the mother, much nervousness and at times spasms. Severe attacks were followed by the passings of the maggots in all stages of development and in quantities sometimes amounting to a cupful.

Other cases have been reported by various authors. Recently Bryan (*21*), in reporting a case of 2 years' duration, suggested that the maggots might be reproducing within the digestive tract by paedogenesis.

According to Townsend (*153, pt. VI, p. 74*) this is the only species of *Sarcophaga* known to be capable of completing its development in the human intestine. Keilin (*65*) suggests that it feeds on partially digested and decomposed food in the intestine rather than being truly parasitic. However, Bryan's examination of the colon wall of his patient by means of a sigmoidoscope showed the entire surface covered with ulcers, and an autopsy on a dog suffering from parasitism by this fly showed the intestinal wall considerably damaged. The parasite therefore seems capable of causing considerable injury.

### SARCOPHAGA PLACIDA Aldrich

GEOGRAPHICAL DISTRIBUTION.—Neotropical Region: Texas (Brownsville), Canal Zone, Panama.

**Pathogenesis.**—This species has been recorded as occurring in necrotic wound tissue in man in Panama. One case of ear myiasis has been recorded from the Canal Zone.

### SARCOPHAGA PLINTHOPYGA Wiedemann

(Fig. 20)

SYNONYMS.—*Sarcophaga robusta* Aldrich; *Hystricocnema plinthopyga* (Wiedemann) of Townsend's Manual.

RECOGNITION CHARACTERS.—Rather easily recognized by the following combination of characters, there is usually one frontal bristle below the anterior points of the frontalia; the postsutural dorsocentrals consist of two strong bristles near the scutellum, preceded by about three weaker ones; the hind femur of the male bears short spinelike bristles in several rows on the under side; vein $r_1$ is bare; the hypopygium is red and unusually large, the first segment being especially robust. Length, 9–15 mm.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Nova Scotia, Maryland, District of Columbia, Florida, Kansas, Texas, Utah, Nevada, New Mexico, Arizona, Washington, California. Neotropical Region: Mexico, Baja California, Guatemala, Costa Rica, Panama, Canal Zone, Bahama Islands, Cuba, Jamaica, Dominican Republic, Puerto Rico, Leeward Island (St. Thomas, Antigua), Barbados, Galapagos Islands, Ecuador, Venezuela, British Guiana, Dutch Guiana, Brazil (southward to São Paulo).

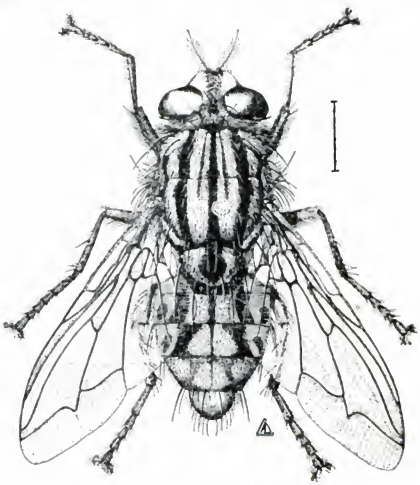

FIGURE 20.—*Sarcophaga plinthopyga*, adult male.

**Pathogenesis.**—The larvae differ in their feeding habits and are commonly found on carcasses or as parasites in the bodies of insects.

However, they frequently attack old and festered sores in man and animals, or invade diseased body openings. According to Patton this is a notorious myiasis-producing species in British Guiana. In Texas it has been reported as infesting rabbits and other animals and causing serious damage to tissues. Roberts (*121*) has reported finding 583 larvae in an old gunshot wound in a rabbit, in association with a few *Callitroga*, and he says that the infestation was such that it would have proved fatal had they not been removed.

### SARCOPHAGA LAMBENS Wiedemann

SYNONYMS.—*Sarcophaga sternodontis* (Townsend); *Sarcophaga pyophila* Neiva and Gomes; *Sarcodexia sternodontis* Townsend.

RECOGNITION CHARACTERS.—Adult: The parafacials are about half as wide as the clypeus; the palpi are black; there are two or three frontal bristles below the anterior angles of the frontalia, and three or four rows of setulae behind the eyes on the upper half of the occiput. Anterior acrosticals are absent, or at most there is a pair just before the suture; there are four pairs of postsutural dorsocentrals, the first two of these weak; the scutellum has a pair of cruciate apical bristles in addition to the lateral ones. The epaulet is black, vein $r_1$ without setulae, and the hind tibia of the male without long villous hairs. The hypopygium is small, the first segment being blackish and the second red; the forceps are yellow for their entire length, very wide, and of a very characteristic form, the apex being strongly bent forward and truncated.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: South Carolina, Georgia, Florida, Mississippi, Missouri, Louisiana. Neotropical Region: Mexico, British Honduras, Honduras, El Salvador, Panama, Canal Zone, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, St. Vincent, Tobago, Grenada, Trinidad, Gorgona Island, Colombia, Ecuador, Venezuela, British Guiana, Brazil, Peru, Bolivia, Paraguay, Argentina.

**Pathogenesis.**—The larvae breed in various substances, including carrion and excrement; they have been found to be parasitic on a large number of insects. Cases of wound and cutaneous myiasis appear to be fairly common. Neiva and Gomes de Faria (*93*) report a case in which larvae had attacked a suppurating contusion in the right parietal region of a 10-year-old girl, the suppuration being favored by the long hair. A case of auricular myiasis in a 11-month-old child in the Canal Zone has been reported. This species is said to attack wounds and ulcers in man in South America, and has been reported from wounds of cattle in Florida.

### SARCOPHAGA CHRYSOSTOMA Wiedemann

SYNONYM.—*Chrysostomomyia chrysostoma* (Wiedemann) of Townsend's Manual.

GEOGRAPHICAL DISTRIBUTION.—Confined to the Neotropical Region: Mexico, Baja California, Honduras, Nicaragua, Costa Rica, Panama, Canal Zone, Virgin Islands, Jamaica, Tobago, Trinidad, Gorgona Island, Colombia, Ecuador, Venezuela, British Guiana, Brazil, Peru, Chile. Also recorded from Argentina, but the record is questionable. Very common in parts of its range (e. g., Tampico, Mexico, British Guiana, and the coast of Brazil).

**Pathogenesis.**—Said by Patton to be a notorious myiasis producer in British Guiana.

### SARCOPHAGA MISERA Walker
and Related Forms

**Status of Species.**—In this group, which, according to Senior-White, Aubertin, and Smart (*139*), occurs in all parts of the world

except the Neotropical Region, 17 forms have been described. Authors differ as to how many of these forms to accept and as to whether to give them specific or only subspecific status. It is difficult to separate them, the separation being based mainly on characters of the male terminalia. No attempt will be made here to unravel this taxonomic puzzle, and it should be borne in mind that the nomenclature, biology, and distribution of the species, as discussed here, is only tentative.

GEOGRAPHICAL DISTRIBUTION.—Because of the close similarity of the various forms, many of the locality records, as well as the identification of the myiasis producers, are subject to question. The following distribution is for species reported to be involved in human myiasis and is based on what are probably authentic records:

*Sarcophaga misera* Walker (synonym, *S. dux* Thomson, *S. ceylonensis* Parker). Type locality of *S. dux*, Hawaii; of *S. misera* (female), Australia; of *S. ceylonensis*, Ceylon. Records from the Nearctic and most of those from the Ethiopian and Palaearctic Regions probably should be referred to other forms. Palaearctic Region: Daghestan, China. Oriental Region: India, Ceylon, Malay States, Taiwan, Philippine Islands, Java, Bali. Ethiopian Region: Seychelles, Chagos Islands. Australian Region: South Australia, Queensland, New South Wales, Victoria, Lord Howe Island, Solomon Islands, Guam, Samoa, Fiji, Hawaiian Islands.

*Sarcophaga exuberans* Pandellé. Type from southern France. Nearctic Region: Nova Scotia, Quebec, British Columbia, New Hampshire, Massachusetts, Connecticut, New York, Ohio, Texas, Washington, Oregon, California. Palaearctic Region: England, Spain, France, Corsica, Hungary, Yugoslavia, Bulgaria, Greece, southern Russia (Crimea, Novorossisk), Daghestan, Azores, Canary Islands, Tunisia, Egypt, Palestine. Ethiopian Region: Anglo-Egyptian Sudan, Uganda, Southern Rhodesia, South-West Africa, South Africa.

*Sarcophaga harpax* Pandellé. Type from Russia. Widespread, but records are not abundant. Nearctic Region: Quebec, Alberta, British Columbia, Massachusetts, Idaho, Washington. Palaearctic Region: Netherlands, Germany, Austria, Bulgaria, Italy, Yugoslavia, Russia (southern part and the Caucasus), Japan. Oriental Region: India, Ceylon, the Malay States, Taiwan, Philippine Islands. Ethiopian Region: Damaraland, South-West Africa. Australian Region: Guam, Samoa, Fiji, Hawaiian Islands.

*Sarcophaga tuberosa* Pandellé. Type from southern France. Nearctic Region: Manitoba, Connecticut, Montana, Utah, Washington, California. Palaearctic Region: France, Corsica, Finland, Denmark, Germany, Czechoslovakia, Hungary, Bulgaria, Russia (southern part), Georgia (Abkhasia), Morocco, Algeria, Egypt, Kazak, Uzbek, Kirghiz, eastern Siberia, China, Japan. Ethiopian Region: Madagascar, Seychelles.

**Pathogenesis.**—Occasionally members of this group may produce myiasis, but they are normally carrion feeders. *S. misera* has been reported as producing myiasis in the ear, mastoid, intestine, and skin, *S. exuberans* in the eye, and *S. tuberosa* in the skin. *S. misera* is a sheep maggot of secondary importance in Australia.

### SARCOPHAGA CRASSIPALPIS Macquart

(Fig. 14, larva)

SYNONYMS.—*Sarcophaga securifera* Villeneuve; *Parasarcophaga securifera* (Villeneuve).

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, District of Columbia, Virginia, Georgia, Florida, Ohio, Texas. Neotropical Region: Uruguay, Argentina. Palaearctic Region: Italy, Corsica, Hungary, Yugoslavia, Rumania, Russia, (Ukraine and Crimea), Georgia, Armenia, Iran, Kazak, Uzbek, Turkmen, Kirghiz, Siberia, Far Eastern province of Asiatic Russia, Tibet, China, Manchuria. Ethiopian Region: South Africa. Australian Region: New South Wales.

**Pathogenesis.**—This species occurs in traumatic dermal myiasis in man and animals. In Serbia it has been reported as occurring in wounds already infested with *Wohlfahrtia magnifica*.

### SARCOPHAGA BARBATA Thomson

SYNONYMS.—*Parasarcophaga barbata* (Thomson); *Sarcophaga falculata* Pandellé; *Sarcophaga argentina* Brèthes.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Quebec, Massachusetts, New York, New Jersey, Pennsylvania, District of Columbia, Georgia, Indiana, Illinois, Iowa, Missouri, Kansas, Texas, Oregon. Neotropical Region: Uruguay, Argentina. Palaearctic Region: England, France, Corsica, Denmark, Germany, Austria, Yugoslavia, Rumania, European Russia, the Caucasus, Georgia, north India, Canary Islands, Madeira, Algeria, Egypt, Palestine, Iran, Tibet. Australian Region: Hawaiian Islands.

RECOGNITION CHARACTERS.—Adult: There are two rows of black hairs behind the eyes; the presutural acrosticals are absent, and the postsutural ones represented only by the prescutellar pair; two postsutural dorsocentrals are well developed and situated close to the suture, although three or four weak ones may be present in front of these. The legs are black; the hind tibia of the male is fringed with long black hair; the middle tibia has only ordinary hair. Vein $r_1$ is bare. The first two abdominal segments lack strong median marginal bristles. Length, usually 8–15 mm. Larva: The larva has been figured and described by Hafez (*46, p. 200–204*) and by Mazza and coworkers (*87*), but because of the lack of knowledge of the larvae of this genus, no diagnostic characters can be given.

**Pathogenesis.**—This species breeds ordinarily in carrion and has been reported as a parasite on several species of insects. It is known to larviposit commonly in wounds of man and animals. In Serbia it has been reported in wounds in association with *Wohlfahrtia magnifica*. Several cases of myiasis in Argentina have been described by Mazza and his associates (*87*), in which it appears that the larvae, though usually associated with *Callitroga americana* (C. and P.), may be primary invaders. Because of the large size and rapid development of the larvae, they can cause both extensive and deep lesions, sometimes penetrating to the bone or to a depth of 1 or 2 inches into the muscle. Because of the crippling action it is one of the most serious of the myiasis-producing *Sarcophaga*.

### SARCOPHAGA BULLATA Parker

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Quebec, British Columbia, Maine, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Florida, Mississippi, Ohio, Indiana, Illinois, Iowa, Missouri, North Dakota, South Dakota, Kansas, Louisiana, Texas, Idaho, Colorado, Utah, New Mexico, Washington, Oregon, California.

**Pathogenesis.**—This species occurs commonly in the wounds of animals, especially in the South, and has been reported in dermal myiasis in man. Dove (*34*) records two cases in necrotic wounds in man in the Southern States. Several cases of intestinal myiasis in man have been attributed to this species, and they may be authentic, since this is a close relative of *S. haemorrhoidalis* and possibly similar in its biology.

### SARCOPHAGA COOLEYI Parker

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Saskatchewan, Alberta, British Columbia, New York, Virginia, Georgia, Florida, Michigan, Kansas, Montana, Idaho, Wyoming, Colorado, Utah, Washington, Oregon, California.

**Pathogenesis.**—Adult flies of this species were reared from larvae taken from the ear of a man in Saskatchewan.

### SARCOPHAGA STRIATA (Fabricius)

SYNONYMS.—*Sarcophaga haematodes* Meigen; *Ravinia striata* (Fabricius); *Sarcophaga sulcata* Robineau-Desvoidy.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: England, Portugal, Spain, France, Netherlands, Italy, Corsica, Sardinia, Sicily, Malta, Germany, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, Bulgaria, European Russia (southern part north to Leningrad Moscow, and the Tartar and Chuvash Republics), Azerbaijan, north Caucasus, Azores, Canary Islands, Algeria, Tunisia, Libia, Egypt, Dodecanese, Syria, Palestine, Arabia, north India (Kashmir and Himalayas east to Darjeeling), Uzbek, Turkmen, Tadzhik, Irkutsk, Amur Oblast, Ussuri, Mongolia, China. Common through the warmer parts of the Palaearctic Region.

**Pathogenesis.**—This species has been reported by Castellani and Chalmers (*25, p. 1629*) as causing gastrointestinal myiasis, but this record is open to question. The larvae normally breed in carrion, but have been reported in wound myiasis.

### SARCOPHAGA FERTONI Villeneuve

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Spain, France, Italy, Corsica, Hungary, Rumania, Algeria, Tunisia, Egypt.

**Pathogenesis.**—This species has been recorded in wound myiasis.

### SARCOPHAGA RUFICORNIS (Fabricius)

SYNONYM.—*Liopygia ruficornis* (Fabricius).

GEOGRAPHICAL DISTRIBUTION.—Oriental Region: Ceylon, Chagos Islands, India, Malay States, Taiwan, Philippine Islands, China (Hong Kong). Ethiopian Region: Northeast Africa, Socotra.

**Pathogenesis.**—This species is said by Castellani and Chalmers (*25, p. 1639*) to cause an occasional very severe form of dermal myiasis in India. Sinton (*142*) reports this species in association with "*Chrysomyia dux*" (*C. bezziana?*) from a septic wound behind the ear of a dog. Sinton gives an extensive description of the larva, with illustrations. Patton (*102*) states that cutaneous myiasis caused presumably by this species is reported to be common in south India, especially on the east coast. It has also been reported in intestinal myiasis.

### SARCOPHAGA PEREGRINA Robineau-Desvoidy

SYNONYMS.—*Sarcophaga fuscicauda* Böttcher; *Boettcherisca peregrina* (Robineau-Desvoidy).

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: China, Manchuria (Port Arthur), Japan. Oriental Region: India, Malay States (Perak), Riouw Archipelago, Taiwan, Philippine Islands, Java. Australian Region: South Australia, Queensland, New South Wales, New Guinea, Samoa, Fiji, Hawaiian Islands.

**Pathogenesis.**—This species has been known to larviposit in wounds in man. It breeds in a wide variety of substances, including meat and human excrement. It is said to be almost as closely associated with man in certain tropical regions as the housefly (*Musca domestica* L.). A case of intestinal myiasis has been recorded, but the record must be questioned; stools are easily contaminated by species breeding in human excrement.

### SARCOPHAGA NODOSA Engel

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: Southern Rhodesia (common); South Africa.

**Pathogenesis.**—Normally the larvae breed in carrion and in the bodies of insects, but one case of auricular myiasis in man has been reported.

### SARCOPHAGA FROGGATTI Taylor

GEOGRAPHICAL DISTRIBUTION.—Oriental Region: Philippine Islands. Australian Region: Western Australia, Northern Territory, Queensland, New South Wales, Samoa.

**Pathogenesis.**—Though normally a carrion feeder, it is a secondary parasite of sheep in tropical and subtropical Australia. It is included here because of the possibility that it might be involved in human myiasis.

### SARCOPHAGA CARNARIA (Linnaeus)

RECOGNITION CHARACTERS.—Adult: The following characters will distinguish it from most Palaearctic species: There are four distinctly developed post-sutural dorsocentrals, although the hind two are a little stronger than the front two; the second, as well as the third and fourth, abdominal segment is provided with median marginal bristles; and the male genitalia are black or distinctly blackish. Two subspecies have been recognized, but they are not considered here.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Widespread throughout most of the region, but, according to Rohdendorf (*124*), absent from China and Japan. Ireland, Scotland, England, Portugal, Spain, France, Netherlands, Switzerland, Italy, Sicily, Finland, Estonia, Lithuania, Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, Bulgaria, Russia (all parts of European Russia north to the Timansk tundra), Georgia, Azerbaijan, Armenia, Morocco, Libia, Egypt, Syria, Palestine, Iran, Kazak, Uzbek, Turkmen, Tadzhik, northern Urals, Siberia (Abakan, Lake Teletskoe, Marlinsk, Minusinsk, etc.), Lake Baikal, Irkutsk, Yakutskaya Republic (Yakutsk, Zhigansk), Mongolia.

**Pathogenesis.**—This species is a common cause of myiasis in some parts of its range. In Britain it is a sheep maggot and in Italy and Sicily it is said to be common in wound myiasis. Larvae will attack wounds and body openings; cases of myiasis of the ear, eye, nasal cavities, mouth, and vagina are recorded. Portchinsky states that many cases attributed to this species are really due to *Wohlfahrtia magnifica;* but enough cases outside the range of that species, and cases authenticated by the determination of adult specimens, are on record to make *Sarcophaga carnaria* an etiological agent of some importance. Several cases of supposed intestinal myiasis have been recorded, but these are probably due either to misidentification or to contamination of stools.

### SARCOPHAGA ALBICEPS Meigen

SYNONYM.—*Parasarcophaga albiceps* (Meigen).

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Scotland, England, Spain, France, Netherlands, Italy, Finland, Germany, Austria, Hungary, Czechoslovakia, Yugoslavia, Rumania, Bulgaria, Russia (south of Leningrad), north Caucasus, Georgia (Abkhasia), Egypt, Sinai Peninsula, Palestine, Siberia (Omsk, Minusinsk), Altai Mountains, Irkutsk, Ussuri, Turkestan, China, Japan. Oriental Region: Indo-China, India, Ceylon, Burma, Taiwan, Philippine Islands, Java, Lombok. Ethiopian Region: Tanganyika. Australian Region: New Guinea, Sakeemi, Siwi, Hawaii, Guadalcanal, Samoa, New Britain.

**Pathogenesis.**—Normally breeds in carrion and excrement, but has been recorded in traumatic myiasis in a bull.

### SARCOPHAGA HIRTIPES Wiedemann

SYNONYM.—*Parasarcophaga hirtipes* (Wiedemann).

GEOGRAPHIQAL DISTRIBUTION.—Palaearctic Region: Germany, Syria, Palestine, Arabia, Iraq, Iran, Uzbek, Turkmen, Tadzhik, China (Szechwan). Oriental

Region: Baluchistan. Ethiopian Region: French Guinea, Anglo-Egyptian Sudan, Eritrea, Italian Somaliland, Socotra, Mozambique, Southern Rhodesia, South Africa (Transvaal [Pretoria], Cape of Good Hope).

**Pathogenesis.**—According to Salem this species occurs accidentally in intestinal myiasis. In one case in Egypt larvae passed in stools pupated at once, but no mention was made of the time that had elapsed before the stools were brought in. The larvae commonly occur in the excrement of man and animals; they also occur in decaying animal and vegetable matter, including carcasses and melons. Cuthbertson states that the females often appear at wounds of cattle and sheep in Rhodesia, although this species does not seem to produce wound myiasis.

### SARCOPHAGA BECKERI Villeneuve

SYNONYM.—*Parasarcophaga beckeri* (Villeneuve).

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: France, Italy, Bulgaria, Greece, Canary Islands, Morocco, Algeria, Tunisia, Tripolitania, Egypt. Ethiopian Region: Cameroun, Belgian Congo, Southern Rhodesia, South Africa.

**Pathogenesis.**—Onorato (*96*) records a case where maggots of this species invaded scalp lesions resulting from trichophytosis; he also cites a similar previous record. Patton says that in Europe the eating of food infested with these maggots occasionally causes human enteric myiasis.

TABLE 4.—*Geographical distribution of the species of Sarcophaga according to Wallace's Zoogeographical Regions*

| Species | Palaearctic | Nearctic | Neotropical | Ethiopian | Oriental | Australian |
|---|---|---|---|---|---|---|
| *albiceps* Meigen | x | | | x | x | x |
| *barbata* Thomson | x | x | x | | | x |
| *beckeri* Villeneuve | x | | | x | | |
| *bullata* Parker | | x | | | | |
| *carnaria* (Linnaeus) | x | | | | | |
| *chrysostoma* Wiedemann | | | x | | | |
| *codeyi* Parker | | x | | | | |
| *crassipalpis* Macquart | x | x | x | x | | x |
| *exuberans* Pandellé | x | x | | x | | |
| *fertoni* Villeneuve | x | | | | | |
| *froggatti* Taylor | | | | | x | x |
| *haemorrhoidalis* (Fallén) | x | x | x | x | | x |
| *harpax* Pandellé | x | x | | x | x | x |
| *hirtipes* Wiedemann | x | | | x | x | |
| *lambens* Wiedemann | | x | x | | | |
| *l'herminieri* (Robineau-Desvoidy) | | x | x | | | x |
| *misera* Walker | x | ? | | x | x | x |
| *nodosa* Engel | | | | x | | |
| *peregrina* Robineau-Desvoidy | x | | | | x | x |
| *placida* Aldrich | | | x | | | |
| *plinthopyga* Wiedemann | | x | x | | | |
| *ruficornis* (Fabricius) | | | | x | x | |
| *sarraceniae* Riley | | x | | | | |
| *striata* (Fabricius) | x | | | | | |
| *tuberosa* Pandellé | x | x | | x | | |

## The Family CALLIPHORIDAE

The family Calliphoridae includes the familiar bluebottle and greenbottle flies, or blowflies. Recent American authors have, for the most part, used the family name in the sense in which it is here employed, although Curran has united it with the Sarcophagidae to form the family Metopiidae. In Europe the family has been considered either as a separate unit or as part of the Muscidae or the

Larvaevoridae (Tachinidae). Townsend (*153, pt. V, p. 122*) uses the name Calliphoridae in a more restricted sense to include only the Calliphorini and the Chrysomyini; this would exclude such genera as *Pollenia*, *Auchmeromyia*, and *Cordylobia*, to which that author gives a separate family status.

The Calliphoridae include a large number of species of metallic blue, green, or copper flies of medium size. Some species are otherwise colored or nonmetallic, however, and some flies, such as the metallic Muscini and certain larvaevorids, superficially resemble the blowflies.

In the adult the arista is plumose, the hairs being usually long and extending almost to its apex; there is no postscutellum (except in some genera not treated here); hypopleural and pteropleural bristles are present; there are three sternopleurals, two in front and one behind; there are two notopleurals, rarely an adventitious third; vein $m_{1+2}$ bends strongly forward, greatly narrowing but usually not closing the apical cell; and the first abdominal sternite overlaps the lateral margins of the tergites.

The larvae are for the most part scavengers feeding on decaying animal matter; some, however, are accidental, facultative, or obligatory parasites on vertebrates, and some may attack invertebrates. In form they are, with rare exceptions, of the usual muscoid type; the posterior end is truncated with usually three pairs of tubercles above and three below, with an additional smaller pair above the three of the lower series; the posterior spiracles are not situated in a depression, as in the Sarcophagidae; the spiracular slits are elongated, slender, and subparallel.

The taxonomic literature is extensive. Hall (*49*) has monographed the North American species; his work, recently published, includes a treatment of the larval as well as the adult stages, with much information on the biology of the species. The second- and third-stage larvae of the American species are described by Knipling (*74*). Among the many European works that of Séguy (*135*) will be found useful. The Oriental species are described by Senior-White, Aubertin, and Smart (*139*); the South Pacific islands and Australia by Bezzi (*16*); the larvae by Fuller (*41, p. 78*); and the New Zealand species by Miller (*90*).

## KEY TO THE GENERA

ADULTS

1. Base of the radius (before the humeral cross vein) ciliated posteriorly above (figs. 4 and 5) ..... 2
   Base of the radius bare posteriorly above ..... 6
2. Hind coxae pilose posteriorly; green to violet-green species, with 3 prominent black longitudinal vittae on the mesonotum ..... 3
   Hind coxae bare posteriorly; green to bluish-black species, sometimes with transverse bands or 2 narrow longitudinal vittae or both on the mesonotum, but never marked as above ..... 4
3. Palpus short and filiform, not nearly reaching the margin of the epistoma ..... *Callitroga* Brauer
   Palpus elongated and clavate, almost reaching the margin of the epistoma ..... *Paralucilia* Brauer and Bergenstamm
4. Lower squama pilose above ..... *Chrysomya* Robineau-Desvoidy (including *Microcalliphora*)
   Lower squama bare ..... 5

5. Mesonotum convex; mesothoracic spiracle with bright orange hair; preacrostical bristles well developed ..... *Phormia* Robineau-Desvoidy
Mesonotum flattened on the disc; mesothoracic spiracle with dark hair; preacrostical bristles absent or vestigial ..... *Protophormia* Townsend
6. Propleura bare; nonmetallic species ..... 7
Propleura pilose ..... 10
7. Prosternum pilose; haustellum somewhat swollen; yellowish species, with only ordinary pile ..... 8
Prosternum bare; haustellum not at all swollen; blackish species, with abundant crinkly yellowish hairs on the sides and dorsum of the thorax ..... *Pollenia* Robineau-Desvoidy
8. Vein $r_5$ ciliated almost to cross vein *r-m;* a small but distinct costal spine present; eyes of both sexes broadly separated, the frontalia in the male not narrowed posteriorly; second abdominal segment especially long (fig. 36) ..... *Auchmeromyia* Brauer and Bergenstamm
Vein $r_5$ ciliated less than halfway to cross vein *r-m;* costal spine absent; eyes of the male but narrowly separated, the frontalia almost obliterated behind; second abdominal segment of ordinary length ..... 9
9. Front of male narrow, the eyes almost contiguous; proclinate fronto-orbitals present in the female ..... *Cordylobia* Grünberg
Front of male about one-fourth the head width; proclinate fronto-orbitals absent in the female ..... *Stasisia* Surcouf
10. Lower squama bare above ..... 11
Lower squama pilose above ..... 12
11. Subcostal sclerite with only soft pubescence ..... *Phaenicia* Robineau-Desvoidy
Subcostal sclerite pilose ..... *Lucilia* Robineau-Desvoidy
12. Abdomen entirely metallic blue, green, or violet ..... 13
Abdomen wholly nonmetallic, or at least broadly yellow on the base, sides, and venter ..... *Calliphora* Robineau-Desvoidy (broad sense, in part)
13. Scutellum with three strong lateral bristles ..... *Cynomyopsis* Townsend
Scutellum with at least four strong lateral bristles ..... *Calliphora* Robineau-Desvoidy (in part)

### LARVAE (Nearctic Region, Second Stage) [4]

1. Oral hooks tapering to a point ..... 2
Oral hooks enlarged near the tips, then tapering beyond the enlargement ..... *Lucilia, Phaenicia, Calliphora, Cynomyopsis*
2. Tracheal trunks leading from the posterior spiracles pigmented, dark brown to black (fig 21, *A*) ..... *Callitroga americana* (Cushing and Patton)
Tracheal trunks leading from the posterior spiracles not pigmented ..... 3
3. Dorsal spines present on posterior margin of segment 11 ..... 4
Dorsal spines absent on posterior margin of segment 11 ..... 5
4. Dorsal spines absent on posterior margin of segment 10.
*Phormia regina* (Meigen)
Dorsal spines present on posterior margin of segment 10.
*Protophormia terrae-novae* (Robineau-Desvoidy)
5. Ratio of distance between inner tubercles on upper margin of posterior cavity and distance between inner and median tubercles on each side approximately 1.5 to 1 ..... *Callitroga macellaria* (Fabricius)
Ratio of distance between tubercles mentioned above approximately 1.1 to 1 ..... *Paralucilia wheeleri* (Hough)

### LARVAE (Nearctic Region, Third Stage) [5]

1. Peritreme of posterior spiracle incomplete and not enclosing the button, the latter sometimes poorly defined (figs. 32, *B* and 35, *E*) ..... 2
Peritreme of posterior spiracle complete, though sometimes weakened in the area of the button (fig. 41, *B*) ..... 6

[4] Modified from Knipling (74) and Hall (49).
[5] Modified from Hall (49) and Knipling (74).

2. Posterior margin of segment 11 without dorsal spines; posterior spiracle without a definite button ..... 3
Posterior margin of segment 11 with dorsal spines; posterior spiracle with a definite button ..... 5
3. Tracheal trunks leading from posterior spiracle not pigmented (fig. 21, *B*) ..... 4
Tracheal trunks leading from posterior spiracles pigmented, dark brown to black (fig. 21, *A*) ..... *Callitroga americana* (Cushing and Patton)
4. Accessory oral sclerite absent (fig. 22) ..... *Callitroga macellaria* (Fabricius)
Accessory oral sclerite present (fig. 6, *B*) ..... *Paralucilia wheeleri* (Hough)
5. Dorsal spines present on posterior margin of segment 10; larger tubercles on upper margin of posterior cavity distinctly longer than half the width of one posterior spiracle.
*Protophormia terrae-novae* (Robineau-Desvoidy)
Dorsal spines absent on posterior margin of segment 10; length of above-mentioned tubercles less than half the width of one posterior spiracle ..... *Phormia regina* (Meigen)
6. Peritreme of posterior spiracles weakly sclerotized.
*Pollenia rudis* (Fabricius)
Peritreme of posterior spiracles strongly sclerotized ..... 7
7. Accessory oral sclerite absent ..... 8
Accessory oral sclerite present (fig. 6, *B*) ..... 10
8. Pharynx without a pigmented area below the posterior extremity of the ventral horn ..... *Lucilia illustris* (Meigen)
Pharynx with a prominent pigmented area below the posterior extremity of the ventral horn ..... 9
9. Inner tubercles on the upper margin of the posterior cavity separated by a distance approximately equal to the distance between the inner and outer tubercles ..... *Phaenicia pallescens* (Shannon)
Inner tubercles on the upper margin of the posterior cavity separated by a distance approximately equal to the distance between the inner and median tubercles ..... *Phaenicia sericata* (Meigen)
10. Labial sclerite with toothlike apical portion longer than the greatest width of the basal portion ..... *Calliphora vicina* Robineau-Desvoidy
Labial sclerite with the toothlike apical portion as long as the greatest width of the basal portion ..... *Cynomyopsis cadaverina* (Robineau-Desvoidy)

LARVAE (Ethiopian Region, Third Stage)

1. Grublike species ..... 2
Maggotlike species ..... 4
2. Cuticle devoid of obvious spines and with numerous longitudinal and horizontal sulci (fig. 37, *A*); anterior spiracles not projecting but flush with the surface; posterior spiracles very widely separated, with 3 straight, short, outwardly directed slits (fig. 37, *B*).
*Auchmeromyia* Brauer and Bergenstamm
Cuticle armed with obvious spines; anterior spiracles consisting of membranous stalks bearing a number of small fingerlike processes; posterior spiracles not widely separated, the breathing slits serpentine or sinuous ..... 3
3. Spines of cuticle small and often grouped in transverse rows of 3 or more (fig. 39, *A*); no bar of spiny processes between the oral hooks; toothed plate bearing about 6 small yellow teeth (fig. 40, *A*); posterior spiracle small with 3 short sinuous slits (fig. 40, *B*) ..... *Cordylobia* Grünberg
Spines large and not grouped in transverse rows (fig. 39, *B*); a dark bar of spiny processes present between the oral hooks; toothed plate bearing about 10 yellow-brown teeth arranged in 2 rows (fig. 40, *C*); posterior spiracle rather large, with 3 long serpentine slits, of which at least 1 may show fragmentation into 2 parts (fig. 40, *D*).
*Stasisia* Surcouf
4. Peritreme of posterior spiracles incomplete, the button outside the sclerotized area (figs. 33, *B* and 35, *E*) ..... *Chrysomya* Robineau-Desvoidy
Peritreme of posterior spiracles complete and enclosing the button (fig. 41, *B*) ..... 5
5. Accessory oral sclerite absent ..... *Phaenicia* Robineau-Desvoidy
Accessory oral sclerite present (fig. 6, *B*) ..... *Calliphora* Robineau-Desvoidy

LARVAE (Australian Region, Third Stage)[6]

1. Peritreme closed; the button situated in the peritreme (fig. 41, *B*)..... 2
   Peritreme open; the button indistinct, in the gap of the peritreme (fig. 32, *B*)..... 6
2. Spiracles very large (more than 0.4 mm. across, separated from each other by less than the spiracular length; peritreme scalloped and wide)..... *Neopollenia stygia* (Fabricius)
   Spiracles much smaller (less than 0.3 mm. across)..... 3
3. Spiracles separated by more than the spiracular length; peritreme not scalloped, narrow..... *Neopollenia fallax* (Hardy)
   Spiracles separated by not more than the spiracular length..... 4
4. Peritreme scalloped and fairly wide, with the part around the button projecting prominently; slits far apart; the bottom slit forming an angle of 13° to 15° with the horizontal plane..... *Anastellorhina augur* (Fabricius)
   Peritreme not scalloped, narrow; spiracular plates separated by less than the spiracular length; the bottom slit forming an angle of 32° to 35° with the horizontal plane..... 5
5. Spiracles pear-shaped (that is, longer than broad); peritreme thin and narrow; slits long and thin (fig. 41, *B*)..... *Phaenicia sericata* (Meigen)
   Spiracles rounded, smaller; peritreme thicker and wider; slits shorter and wider..... *Phaenicia cuprina* (Wiedemann)
6. Larvae hairy, that is, with a transverse row of fleshy tubercles discally on each segment (fig. 32, *A*)..... 7
   Larvae smooth, without such tubercles..... *Chrysomya micropogon* (Bigot)
7. Larvae large (up to 16 mm.), very hairy, grayish; peritreme forked at the opening, which is narrow (cf. *C. albiceps*, fig. 32, *B*)..... *Chrysomya rufifacies* (Macquart)
   Larvae smaller (up to 11 mm.), much less hairy, brownish; peritreme opening wide..... *Microcalliphora varipes* (Macquart)

## The Genus CALLITROGA Brauer

(Figs. 21 and 22)

This genus includes the American screwworm flies. In the literature the species have commonly been referred to *Cochliomyia*.

Members of this genus are metallic dull green to bright green or greenish-blue flies of medium size; the head, including the palpi and usually the antennae, is largely orange to yellow; the wings are hyaline. The presence of three prominent longitudinal black stripes on the mesonotum and the short filiform palpi will separate it from related genera.

As far as is known, the genus is strictly American. There are four species, two of which are known to cause myiasis. The following key, adapted from Hall (*49*), will separate the adults:

### KEY TO SPECIES

1. Parafrontalia with light hair anteriorly outside the frontal row of bristles; female with 1 or 2 pairs of proclinate fronto-orbital bristles..... 2
   Parafrontalia with dark hair anteriorly outside the frontal row of bristles; female rarely with fronto-orbital bristles (fig. 23) *americana* (Cushing and Patton)
2. Fourth abdominal segment strongly pollinose laterally; male without fronto-orbital or outer vertical bristles..... 3
   Fourth abdominal segment nearly shining and with only a trace of pollen laterally; male with reclinate fronto-orbital bristles opposite middle of ocellar triangle and with strong outer verticals..... *minima* (Shannon)

[6] After Fuller (*41, p. 78*).

3. Thorax usually bright metallic yellow to blue green, the middorsal stripe of the mesonotum not extending over the scutellum; female usually with two proclinate fronto-orbitals (fig. 24)_____ *macellaria* (Fabricius)
Thorax usually metallic dark blue to black, the middorsal stripe extending over the scutellum; female with one proclinate fronto-orbital bristle *aldrichi* (Del Ponte)
(=*laniaria* Aldrich, not Wiedemann)

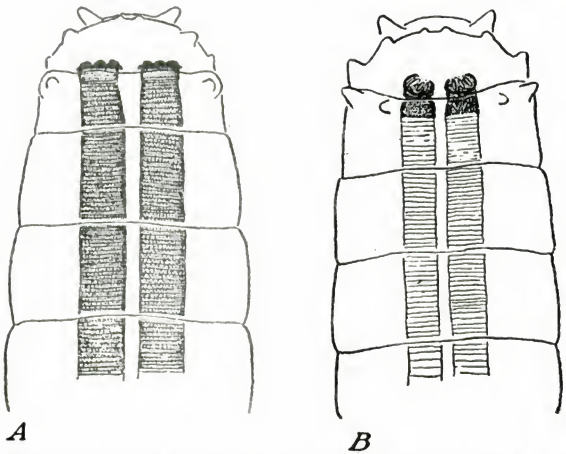


FIGURE 21.—Dorsal view of posterior segments of third-stage larva: *A*, Pigmented tracheal trunks of *Callitroga americana*; *B*, unpigmented tracheal trunks of *C. macellaria*. (After Laake, Cushing, and Parish (77, *p. 11*).)

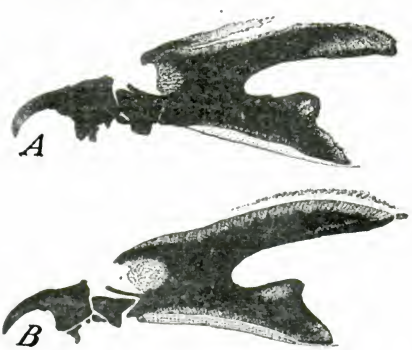


FIGURE 22.—Cephalopharyngeal skeleton of mature third-stage larva, lateral view: *A*, *Callitroga americana*; *B*, *C. macellaria*. (After Laake, Cushing, and Parish (77, *p. 7*).)

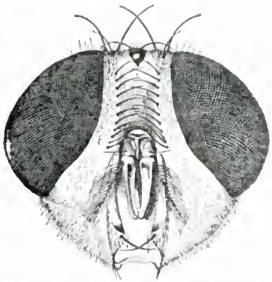

FIGURE 23.—*Callitroga americana*, head of female, front view.

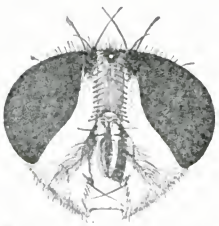

FIGURE 24.—*Callitroga macellaria*, head of female, front view.

## CALLITROGA AMERICANA (Cushing and Patton)

The Primary Screwworm
(Figs. 25 and 26)

SYNONYMS.—*Cochliomyia americana* Cushing and Patton; *C. hominivorax* (Coquerel) of authors; *C. macellaria* (Fabricius) of much of the literature prior to 1933, but not the true *Callitroga macellaria* of Fabricius.

RECOGNITION CHARACTERS.—Adult: This is a bluish to bluish-green species, readily distinguishable from other members of the genus by the black hair on the lower as well as the upper part of the parafrontalia. The basicostal scale is black; the occiput of the female is usually reddish orange to brown and rarely with proclinate fronto-orbital bristles. Length 8–10 mm. Larva: This is a typical muscoid maggot with a cylindrical body which is truncate posteriorly and encircled by bands of spines on the segments. These spines are large and robust, the largest measuring 20 $\mu$ in the first instar, 55 $\mu$ in the second, and 130 $\mu$ in the third; the tracheal trunks leading from the posterior spiracles are pigmented from the juncture with the spiracles through half the length of the last segment in the second instar, and are similarly pigmented through the last three or four segments in the third instar. The mature maggot may be as long as 17 mm.

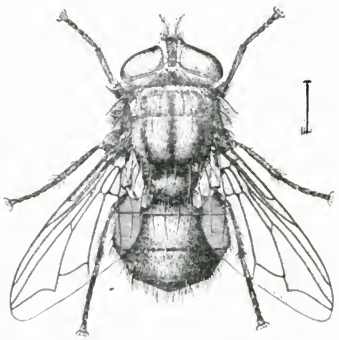

FIGURE 25.—*Callitroga americana*, adult female.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Indiana, Illinois, Kentucky, Minnesota, Wisconsin, Iowa, Missouri, South Dakota, Nebraska, Kansas, Arkansas, Louisiana, Oklahoma, Texas, Montana, Colorado, Utah, Nevada, New Mexico, Arizona, California. Neotropical Region: Mexico, Costa Rica, Panama, Canal Zone, Cuba, Haiti, Dominican Republic, Puerto Rico, Virgin Islands, St. Lucia, Trinidad, Colombia, Venezuela, British and French Guiana, Brazil, Uruguay, Chile, Argentina.

**Biology and Pathogenesis.**—The parasitic habit is obligatory to this species; it cannot exist in carrion. Eggs are deposited in oval masses of 10 to 393 each, usually glued tightly to dry tissue near the surface of a wound. They hatch in 11 to 21 hours. The larvae penetrate the tissue in a characteristic head-downward position, with the posterior spiracles exposed to the outer air; they are gregarious and produce characteristic pocketlike injuries. After feeding from 4 to 8 days, they drop to the ground and enter the soil to pupate. The pupal stage varies from 7 days in summer to 54 days in winter under Texas conditions. The average life cycle in summer at Dallas, Tex., is about 24 days. Adults are known to live 65 days in captivity, although they probably do not usually live so long in nature. They are known to feed on manure, meat, and exudations from wounds.

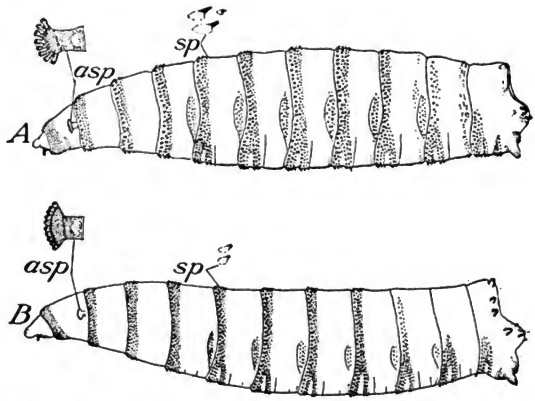


FIGURE 26.—Lateral view of mature third-stage larva: *A*, *Callitroga americana*; *B*, *C. macellaria*. Anterior spiracles and some spines are shown more enlarged. (After Laake, Cushing, and Parish (77).)

This is the most serious myiasis-producing calliphorid in the New World. It is strictly parasitic and attacks only fresh, clean wounds in man or animals. It is a serious plague of livestock, particularly of cattle, sheep, and goats, over a part of its range. When not controlled, an infestation of 20 percent or more of the livestock population may be attained, with mortality in certain classes reaching 20 percent or more of those infested.

In infested areas man is often attacked. In 1935, when a severe outbreak in the South caused more than 1,200,000 cases in livestock in Texas alone, there were 55 recorded human cases and probably twice as many unrecorded ones according to Dove (*34*). Numerous other cases have been reported from various parts of North, Central, and South America.

Any wound however small—even a scratch or a stubbed toenail—may become infested. Larvae have been shown to be capable of entering the unbroken skin of guinea pigs and rabbits, and such an entrance

may explain the case of furuncular myiasis described by Mazza and coworkers (*87, pp. 70–75*), in which four larvae were recovered from a boillike swelling. Larger wounds may become badly infested, and infestation of the navel and vaginal regions may be serious. Infestation of the nasal and frontal regions, and of the eyes, ears, and month often result in death, if untreated. Myiasis of the nasal and frontal sinuses is accompanied by excruciating pains and headaches and by a general swelling of that region.

**Literature.**—For the taxonomy, see Hall (*49*); for biology and immature stages, Hall (*49*), Laake, Cushing, and Parish (*77*), and Mazza and coworkers (*87*); for case histories, Mazza and coworkers (*87*), and Dove (*34*). A large amount of literature on this species has been published under the specific names *C. americana*, *C. hominivorax*, and *C. macellaria*.

### CALLITROGA MACELLARIA (Fabricius)

The Secondary Screwworm Fly; the Common Screwworm Fly

SYNONYMS.—*Chrysomyia macellaria* (Fabricius); *Cochliomyia macellaria* (Fabricius). Many records of this fly in myiasis prior to 1933 refer to *C. americana*.

RECOGNITION CHARACTERS.—Adult: This is a green-bodied species with a predominantly orange head. The hair of the lower half of the parafrontals is yellow and of fine texture; distinct outer verticals and one or two distinct, though small, proclinate fronto-orbitals are present in the female, but both outer verticals and fronto-orbitals are absent in the male. The middorsal longitudinal stripe of the thorax does not extend over the scutellum; the fourth abdominal segment is strongly pollinose laterally. Length, 6–9 mm. Larva: The larva is similar in size and general form to that of *C. americana;* the spines of the integument are smaller, the largest ones averaging about 6 $\mu$ in the first instar, 20 $\mu$ in the second, and 80 $\mu$ in the third; the spines are also paler; the tracheal trunks leading from the posterior spiracles are not pigmented in the second and third instars. Length of mature maggot, up to 17 mm.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Quebec, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Ohio, Indiana, Illinois, Kentucky, Minnesota, Wisconsin, Iowa, Missouri, South Dakota, Nebraska, Kansas, Arkansas, Louisiana, Texas, Montana, Idaho, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico, Yucatan, Baja California, Guatemala, Honduras, Costa Rica, Panama, Canal Zone, Bahama Islands, Cuba, Jamaica, Haiti, Mona Island, Puerto Rico, Virgin Islands, Guadeloupe, Martinique, Barbados, St. Lucia, Trinidad, Colombia, Galapagos Islands, Ecuador, Venezuela, British, French, and Dutch Guianas, Brazil, Ascension Island, Peru, Bolivia, Paraguay, Uruguay, Chile, Argentina, Patagonia.

**Biology and Pathogenesis.**—The eggs are deposited in a yellowish, loosely cemented mass, the number to the mass ranging from 40 to 250 up to 1,000 or more. As in certain other Calliphoridae, several females may form composite masses aggregating thousands of eggs. These eggs may hatch in 4 hours under very favorable conditions. The larvae attain maturity in 6 to 20 days, and then leave the breeding medium and crawl into the soil to pupate. The total developmental period ranges from 9 to 39 days, depending on temperature and humidity. The adult lives from 2 to 6 weeks; it feeds on a variety of foods, from garbage refuse to the nectar of flowers. Adults are usually found in the vicinity of carrion and are most abundant in warm humid areas.

Numerous records of this species producing myiasis of wounds and

752113°—48——5

of the body openings in man can be found in the literature, but undoubtedly many of these refer to *C. americana*. *C. macellaria* is primarily a scavenger and may be very abundant in carrion. In myiasis cases in animals it is a secondary invader; its larvae do not form the typical pocketlike injury characteristic of *C. americana* but often migrate into the wool or hair around the wound. In cases of severe infestation, however, it may produce the death of the animal.

**Literature.**—For the taxonomy see Hall (*49*); for the biology and immature stages see Hall (*49*) and Laake, Cushing, and Parish (*77*).

## The Genus PARALUCILIA Brauer and Bergenstamm

This genus may readily be distinguished by the characters given in the key.

### PARALUCILIA WHEELERI (Hough)

SYNONYM.—*Compsomyiops wheeleri* (Hough).

RECOGNITION CHARACTERS.—The large size (9–11 mm.) and the dark-brown squamae will readily distinguish this species from the only other member of the genus known to occur in North America (*P. fulvipes* (Macquart)), as well as from species of *Callitroga*, with which it has sometimes been confused. For a comparison of the head of the female with that of *C. americana* and *C. macellaria*, see figures 23, 24, and 27.

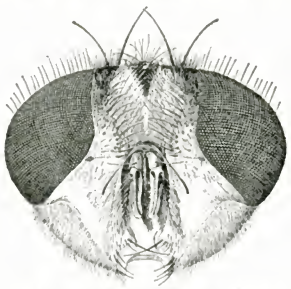

FIGURE 27.—*Paralucilia wheeleri*, head of female, front view.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Texas, Colorado, New Mexico, Arizona, Washington, California. Neotropical Region: Mexico (to the southern part).

**Pathogenesis.**—This species has been recorded in wound myiasis, usually in association with larvae of other myiasis-producing genera. It is probably of little importance.

## The Genus CHRYSOMYA Robineau-Desvoidy

(including MICROCALLIPHORA)

The name of this genus is usually written *Chrysomyia*, but the insertion of the "*i*" is an unwarranted emendation. As treated here, the genus is undoubtedly a composite. *Microcalliphora* is most probably valid, and the same may be true of other segregates, such as *Achoetandrus*. Further taxonomic study is needed before the status

of these groups can be clarified. The name *Pycnosoma* has been used by some authors, but it is an absolute synonym of *Chrysomya*.

The following characters are common to the members of this composite: The flies are of rather small (*Microcalliphora*) to medium size and brilliant metallic green to blue or purple, usually, however, with at least the narrow apices of the abdominal segments opaque black; the eyes are broadly separated in the female, narrowly so or contiguous in the male (except in *Microcalliphora*); the epistoma projects downward and forward; the palpi are well developed and somewhat thickened apically. The mesonotal bristles are weak, the dorsocentrals and acrosticals, except those near the scutellum, being much weaker than the bristles toward the sides of the mesonotum. The posterior coxae are bare behind; the lower squamae are bare above.

In spite of a considerable amount of literature, no thoroughgoing revision of the species of the world has been made. Bezzi's (*17, p. 185*) key includes a large number of Oriental and Australian species.

## KEY TO SPECIES

### ADULTS

1. Vibrissae set very close to the oral margin; small species, usually under 5 mm. in length; body bluish green, the legs yellowish, banded with black ..... *Microcalliphora varipes* (Macquart)
   Vibrissae well above the oral margin; larger species, usually 8 mm. or more in length ..... 2
2. Anterior margin and base of wings deeply infuscated ..... *marginalis* (Wiedemann)
   Wings entirely hyaline ..... 3
3. Mesothoracic spiracle white ..... 4
   Mesothoracic spiracle brown ..... 7
4. Stigmatic bristle present ..... 5
   Stigmatic bristle absent ..... *albiceps* (Wiedemann)
5. Mesonotum in front of the suture with a prominent dull-black L-shaped marking on the left side and the reverse of it on the right ..... *chloropyga* (Wiedemann)
   Mesonotum in front of the suture wholly green or with narrow lengthwise coppery vittae ..... 6
6. Parafacials and facials extensively reddish; parafrontals of male with numerous pale hairs, in several rows, in addition to the very weak bristles ..... *ruficies* (Macquart)
   Parafacials at least in large part black; parafrontals of male with but few scattered hairs in addition to the distinctly developed bristles ..... *putoria* (Wiedemann)
7. Squamae yellowish to dirty gray; front and frontalia of female bulging in the middle, not parallel-sided (fig. 29) ..... 8
   Squamae waxy white; front and frontalia of female parallel-sided (fig. 28); eyes of male without a definite area of smaller facets (fig. 30). ..... *bezziana* Villeneuve
8. Eyes of male with a definite area of smaller facets below (fig. 31); frontalia of female dark brown to black, the parafrontals and parafacials dark grayish ..... *megacephala* (Fabricius)
   Eyes of male without a definite area of smaller facets below; frontalia of female reddish brown, the parafrontals and parafacials yellowish gray ..... *micropogon* (Bigot)

### THIRD-STAGE LARVAE[7]

1. Larvae hairy, that is, with a transverse row of fleshy tubercles medially on each segment (fig. 32, *A*) ..... 2
   Larvae smooth, without such tubercles ..... 4

[7] Key compiled from the literature.

2. Larger larvae (up to 16 mm.); peritreme forked at its opening, which is very narrow (fig. 32)---------- 3
Smaller larvae (up to 11 mm.); peritreme not forked at the opening, which is wide---------- *Microcalliphora varipes* (Macquart)

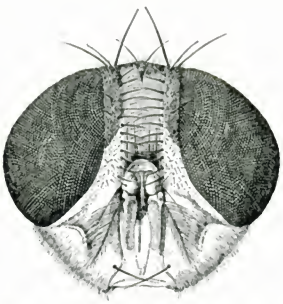

FIGURE 28.—*Chrysomya bezziana*, head of female, front view.

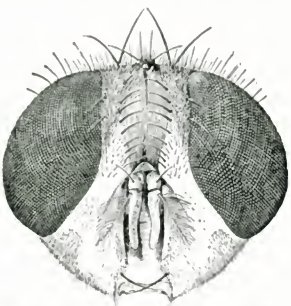

FIGURE 29.—*Chrysomya megacephala*, head of female, front view.

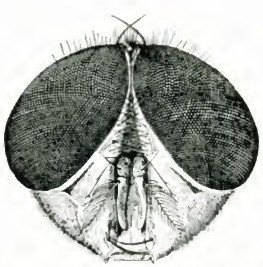

FIGURE 30.—*Chrysomya bezziana*, head of male, front view.

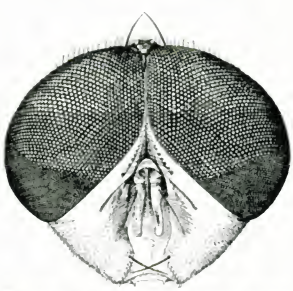

FIGURE 31.—*Chrysomya megacephala*, head of male, front view.

3. Australian and Oriental species---------- *ruffacies* (Macquart)
Palaearctic and Ethiopian, more rarely Oriental, species
*albiceps* (Wiedemann)

4. Larvae creamy yellow; belts of spines strongly developed, the spines recurved (fig. 35); anterior spiracles with 4 to 6, usually 5, fingerlike processes---------- *bezziana* Villeneuve
Larvae whitish to yellow; belts of spines at most moderately developed; anterior spiracles with 10 to 13 fingerlike processes---------- 5

5. Larvae yellow; posterior spiracles closely approximate, separated by about one-fifth the diameter of a spiracle (fig. 33)
*chloropyga* (Wiedemann)
Larvae whitish; posterior spiracles more remote from each other, separated by one-third to one-half the diameter of a spiracle.
*marginalis* (Wiedemann)
*megacephala* (Fabricius)

### MICROCALLIPHORA VARIPES (Macquart)

The Small Green Blowfly

SYNONYM.—*Chrysomyia varipes* (Macquart).

GEOGRAPHICAL DISTRIBUTION.—Australian Region: South Australia, Queensland, New South Wales, Fiji, Tonga.

**Biology and Pathogenesis.**—This species is a scavenger, feeding in carcasses and supposedly predaceous on other dipterous larvae which it may encounter. It is a secondary sheep maggot of little importance in Australia, and is probably not involved in human myiasis.

### CHRYSOMYA MARGINALIS (Wiedemann)

RECOGNITION CHARACTERS.—Adult: This is a bluish-green to purple species with whitish pollen on the thorax and the tip of the abdomen; the head, including the antennae and palpi, is orange, and the wing is blackish at the base and along the anterior margin. Length, about 12 mm. Larva: The mature larva is about 12–14 mm. in length, white and soft, with hardly discernible minute spines encircling the segments; it broadens gradually from the head end, being about 3 mm. wide near the end of the body. The anterior spiracle ends in about 12 processes; the peritreme of the posterior spiracles is very thin.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Cape Verde Islands, Egypt, Syria, Arabia. Oriental Region: Baluchistan, India. Ethiopian Region: Senegal, Sierra Leone, Anglo-Egyptian Sudan, Eritrea, Aden Protectorate, Ethiopia, Italian Somaliland, Socotra, Belgian Congo, Angola, Uganda, Kenya, Tanganyika, Zanzibar, Mozambique, Northern Rhodesia, South-West Africa, Transvaal, Natal, Cape of Good Hope, Madagascar.

**Biology and Pathogenesis.**—This is a common species in Africa. The adults rarely enter houses but are common in butcher shops, where they are attracted by the meat. In the wet season they swarm on cow dung and feces, and persistently feed on liquids exuding from septic sores and screwworm-infested wounds on cattle.

The larvae breed usually in the carcasses of dead cattle. Eggs are laid in batches of 200 to 300, and several females may oviposit together to form masses. The eggs hatch in 24 hours; the larvae then bore into the decomposing flesh, reducing it to a liquid mass. Development is rapid, the larvae maturing in 3 to 4 days after hatching. Pupation takes place in the soil, about half an inch below the surface.

Though primarily scavengers, the larvae may attack living tissue. Sick animals near death are sometimes chosen by the female for oviposition. In some parts of Africa this blowfly occasionally infests human sores with its larvae.

**Literature.**—Cuthbertson (*31*) gives an account of the life history and biology of this fly.

### CHRYSOMYA ALBICEPS (Weidemann)

The Banded Blowfly

RECOGNITION CHARACTERS.—This species is very close to *C. rufifacies*, the adults differing chiefly in the absence of the stigmatic bristle and in the structure of the male genitalia.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Portugal, Spain, Balearic Islands, France, Italy, Corsica, Sardinia, Sicily, Yugoslavia, Bulgaria, Greece, Crete, European Russia (Crimea, Caucasus, and Transcaucasus), Canary Islands, Morocco, Algeria, Tunisia, Libia, Egypt, Turkey, Dodecanese, Syria, Palestine, Arabia, Iraq, Iran, Afghanistan, China. Oriental Region: India. Ethiopian Region: Sierra Leone, French Equatorial Africa, Anglo-Egyptian

Sudan, Eritrea, Ethiopia, Belgian Congo, Angola, Uganda, Kenya, Mozambique, Southern Rhodesia, South-West Africa, Transvaal, Natal, Orange Free State, Cape of Good Hope, Madagascar, Reunion Island, Aldabra Island, Seychelles, Rodriquez.

**Biology and Pathogenesis.**—This is one of the principal sheep maggots of South Africa, where, however, it seems to act as predator on the primary parasites, and to invade only diseased tissue of its vertebrate host. In most parts of its wide range it appears to be

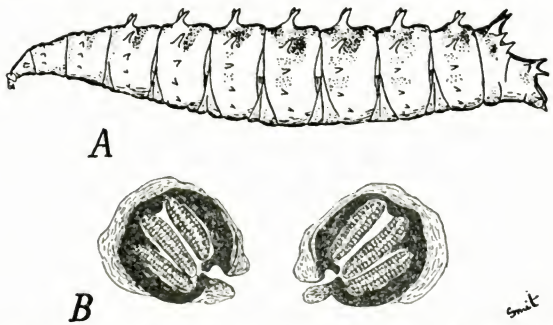


FIGURE 32.—*Chrysomya albiceps:* (*a*), larva; (*b*), posterior spiracles of larva. (After Smit (*143, p. 369*).)

purely a scavenger and the biological equivalent of the Australian *C. rufifacies*.

**Literature.**—Considerable information bearing on the life history and immature stages is given by Smit (*143, p. 310*).

### CHRYSOMYA CHLOROPYGA (Wiedemann)

The Green-tail Bluebottle; the Green-and-blue Blowfly

RECOGNITION CHARACTERS.—Adult: This species is readily recognizable from the characters given in the key, the black L and reverse L of the presutural area of the mesonotum being outstandingly characteristic. The last two abdominal segments are brassy green in contrast to the blue of the rest of the abdomen and of the thorax. Length, 8–10 mm. Larva (fig. 33): The mature larvae are yellowish, about 12 mm. in length, and are distinguished from other species by the strongly sclerotized peritreme of the posterior spiracles. The anterior spiracles terminate in 10 or 11 processes.

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: Belgian Congo, Angola, Kenya, Tanganyika, Southern Rhodesia, South-West Africa, Transvaal, Natal, Orange Free State, Cape of Good Hope.

**Biology and Pathogenesis.**—A female may produce 400 to 500 eggs, or perhaps more. The eggs hatch in from 8 hours to 3 days; the larvae develop rapidly, maturing under South African conditions in 3 days in hot weather. The mature maggot migrates from the flesh to the soil, and there pupates. Smit reared eight generations of this fly in 13 months under natural temperature conditions in South Africa; there it breeds continuously throughout the year, although low winter temperatures affect it adversely.

This is the most important sheep maggot in South Africa. It also occasionally infests wounds in cattle and in man. There is on record one case of intestinal myiasis in man which appears authentic, although determinations were made from the larvae alone.

**Literature.**—Smit (*143*) gives an account of the life history and immature stages of this fly.

### CHRYSOMYA RUFIFACIES (Macquart)

SYNONYMS.—*Achoetandrus rufifacies* (Macquart); *Lucilia tasmaniensis* Macquart. This species has been confused with *Chrysomya albiceps* (Wied.), and the literature on that species from the Australian Region and for the most part from the Oriental Region refers to *C. rufifacies*.

RECOGNITION CHARACTERS.—Adult: Sufficiently characterized in the key. Larva: The larva is one of the hairy maggots of the *C. albiceps* type; that is, the body possesses a median row of fleshy tubercles on each segment, which gives the maggot a hairy appearance. The mature larva is about 14 mm. in length

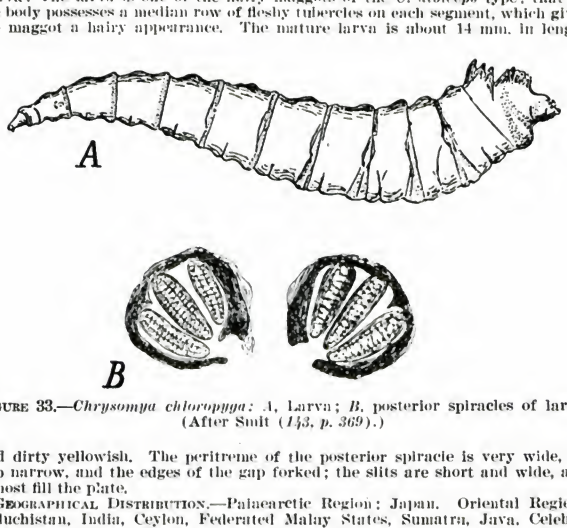


FIGURE 33.—*Chrysomya chloropyga*: *A*, Larva; *B*, posterior spiracles of larva. (After Smit (*143, p. 369*).)

and dirty yellowish. The peritreme of the posterior spiracle is very wide, its gap narrow, and the edges of the gap forked; the slits are short and wide, and almost fill the plate.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Japan. Oriental Region: Baluchistan, India, Ceylon, Federated Malay States, Sumatra, Java, Celebes. Australian Region: Western Australia, North Australia, South Australia, Queensland, Canberra, New South Wales, Victoria, Tasmania, New Zealand, New Caledonia, New Hebrides (Espiritu Santo Island), Saipan, Solomon Islands, Samoa, Fiji, Society Islands, Marquesas Islands, Tonga (Friendly Island), Hawaiian Islands.

**Biology and Pathogenesis.**—This is a sheep maggot fly in Australia but is purely secondary; in fact, there is evidence that in the second and third instars it is a predator upon primary parasites, and may therefore be considered beneficial. This species has been used successfully in the treatment of osteomyelitis, and, if it does invade human tissue, probably does so only as a scavenger.

**Literature.**—The status of this species, which has been confused with *C. putoria* and *C. albiceps*, was clarified by Holdaway (*59, p. 549*).

### CHRYSOMYA PUTORIA (Wiedemann)

SYNONYMY.—This species has been considered by Patton and others as a synonym of *C. albiceps* and *C. rufifacies*, but this is an error.

RECOGNITION CHARACTERS.—Adult: This is a green species with broad black bands at the incisures of the abdominal segments; it may be recognized by the characters given in the key. Length, about 8 mm.

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: Senegal (Dakar), French Guinea, Sierra Leone, Liberia, Ivory Coast, Gold Coast, Nigeria, Anglo-Egyptian Sudan, Ethiopia, Belgian Congo, Uganda, Kenya, Zanzibar, Mozambique, Nyasaland, Southern Rhodesia, Natal.

**Pathogenesis.**—This species is primarily a scavenger. It has been recorded in human wound and nasal myiasis, but these records may be the result of misidentification.

### CHRYSOMYA BEZZIANA Villeneuve

The Old World Screwworm

(Fig. 34)

SYNONYM.—*Pycnosoma bezzianum* (Villeneuve). In the early literature this species was recorded as *Chrysomya megacephala* (F.), so some of the literature on that species really refers to this one.

RECOGNITION CHARACTERS.—Adult: The head is black above, except on the frontalia, but orange on the face, cheeks, antennae, and palpi; the thorax and abdomen are green to bluish purple, with narrow black posterior margins on the intermediate abdominal segments. In the female the front is almost parallel-sided, and the sides of the frontalia do not bulge in the middle (fig. 28); in the male the facets of the eyes are rather uniform, there being no definite upper zone of larger facets and lower zone of smaller ones (fig. 30). The stigmatal bristle is well developed; the mesothoracic spiracle is brownish, and the squamae are waxy white. Length 8–12 mm. Larva (fig. 35): The mature larva is a creamy-yellow maggot, 14–18 mm. in length and with only the usual protuberances; the mouth hooks are strong; the spines in the belts along the incisures are strong, being visible to the naked eye, and recurved, and there are several irregular rows to each belt. The anterior spiracle terminates in 4 or 5 fingerlike processes.

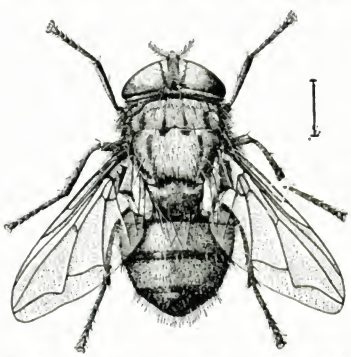

FIGURE 34.—*Chrysomya bezziana*, adult female.

GEOGRAPHICAL DISTRIBUTION.—Oriental Region: India, Ceylon, Burma, Thailand, French Indo-China, Philippine Islands. Ethiopian Region: Gambia, French Guinea, Ivory Coast, Belgian Congo, Uganda, Kenya, Zanzibar, Northern Rhodesia, Southern Rhodesia, Natal (Zululand).

**Biology and Pathogenesis.**—The adults are rarely seen in nature. The females occur in the vicinity of cattle and other mammals; the males feed on the surface liquids of fresh cow dung, on honeydew, and on flowers. The eggs are usually glued to dry skin, in one or more batches, just inside the rim of a wound; they are sometimes deposited on unbroken skin covering bruises or abscesses, or in places soiled by

septic exudations and blood from wounds. The larvae hatch in 18 to 24 hours; after feeding near the surface until the first molt, they burrow deeply into the living tissues, which become liquefied with their advance. The larvae mature in about 6 days, then drop to the ground to pupate within the soil. The duration of the pupal stage varies according to the season; the short winter in the cooler parts of its range is probably spent in this stage. The biotic potential of the fly is enormous; a female may produce 500 to 600 eggs in her lifetime, and there may be eight or more generations a year.

This is the most important myiasis-producing calliphorid of the Old World; according to Cuthbertson it ranks second in importance to

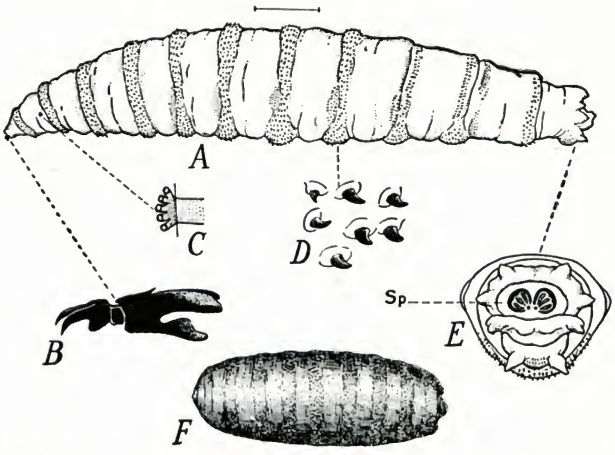


FIGURE 35.—*Chrysomyia bezziana:* *A*, Larva; *B*, cephalopharyngeal skeleton; *C*, anterior spiracle, much enlarged; *D*, spines, much enlarged; *E*, posterior end, showing spiracles; *F*, pupa. (After Cuthbertson (*32*).)

the tsetse flies as a cattle pest in Africa. Cattle are the chief hosts, although it frequently attacks man as well as various domestic and wild mammals.

An open wound is usually chosen for oviposition; a large foul-smelling one may contain several batches aggregating 800 or 1,000 eggs. The evidence indicates that, in spite of statements to the contrary, larvae cannot enter healthy, unbroken skin, although a very small lesion, such as a tick bite, may permit entrance. Diseased body openings, bruises, or tumors produced by elephantiasis may invite oviposition.

The larvae may attack wounds on various parts of the body; in man infestation of head wounds seems most frequent. Because of the number of the larvae and the depth of their penetration, the results may be serious. Infestation of the nose, mouth, ears, eyes, and frontal sinuses are not uncommon in India, and may result in the loss of an

eye or ear. Nasal cases, in particular, may terminate fatally for the host. The genitals may be affected, although this species is not involved in enteric or vesicular myiasis.

In India infestation of the nose, mouth, and accessory sinuses is known as peenash. A swollen face in an otherwise healthy individual, associated with headaches, fever, burning pains in the nasal region, and a sero-sanguineous discharge from the nostrils, should suggest myiasis. Man is apparently attacked with relatively more frequency in India than in other parts of the range of this fly, whereas cattle suffer from it more in Africa. However, a number of human cases have been recorded from that continent.

**Status as a Parasite.**—*Chrysomya bezziana* is a specific myiasis-producing fly; it cannot breed in carrion or excrement and is dependent upon living tissue for its existence.

**Literature.**—Patton (*99, 102*) has given considerable information on the biology of this fly in India, with descriptions of 59 cases of myiasis in man and 71 in animals. For accounts of the biology of the fly in Africa, see Cuthbertson (*31, 32*).

### CHRYSOMYA MEGACEPHALA (Fabricius)

SYNONYMS.—*Pycnosoma megacephala* (Fabricius); *Compsomyia megacephala* (Fabricius); *Chrysomyia dux* (Eschscholtz).

RECOGNITION CHARACTERS.—Adult: The head is black above, except for the frontalia, which are usually reddish; the face and cheeks are orange; the thorax and abdomen are greenish blue with purple reflections, the first abdominal segment and the posterior margins of the second and third being black. The head is unusually broad; in the female the front is much broader than in related species, and its sides, as well as those of the frontalia, distinctly bulge outward in the middle (fig. 29); in the male the upper facets are distinctly larger than the lower ones, the line of demarcation being sharp (fig. 31). The stigmatic bristle is present; the mesothoracic spiracle is brownish; and the squamae are dirty yellow to brown. Length, about 11 mm. Larva: The mature larva is a smooth, whitish maggot similar to *C. bezziana* but readily distinguishable by the much weaker mouth hooks and body spines. The posterior spiracles have a thinner peritreme and its gap at the button is broader; the slits are longer; and there are no breaks in the membrane between the slits. The anterior spiracles end in 10 to 13 fingerlike processes.

GEOGRAPHICAL DISTRIBUTION.—Palearctic Region: Egypt, Iran, China (north to Pelping), Japan. Oriental Region: India, Ceylon, Chagos Islands, Thailand, French Indo-China, Federated Malay States, Taiwan, Philippine Islands, Sumatra, Borneo, Java, Timor, Celebes. Ethiopian Region: Seychelles, Mauritius; other records from this region cannot be accepted without confirmation. Australian Region: North Australia, Queensland, New South Wales, New Zealand, New Hebrides (Espiritu Santo Island), Solomon Islands, Aru, Wokan, Misol, Ternate Islands, Guam, Saipan, Samoa (Apia, Upolu, Savaii), Fiji, Tonga, Hawaiian Islands.

**Biology and Pathogenesis.**—This is a very common household and bazaar pest in the Oriental Region and the Pacific islands, where the adults are said to swarm over meats, sweets, and other foodstuffs. The larvae breed in decomposing animal matter, but occasionally occur in diseased animal tissue. A number of cases of myiasis of wounds, body openings, and sinuses have been attributed to this species, although most of them should probably be referred to *C. bezziana*. Because of the confusion as to the identity of these two species, many records in literature are erroneous.

*Chrysomya megacephala* may breed in certain foodstuffs; furthermore, the larva has been shown to be able to endure oxygen deficiency resulting from immersion in human urine for as many as 2 days.

Strickland and Roy (*146*) experimentally produced a fatal enteric myiasis with this species in a puppy. It is conceivable that it may occasionally be involved in human enteric myiasis.

### CHRYSOMYA MICROPOGON (Bigot)

The Steel-blue Blowfly

Recognition Characters.—Adult: This is a broad, robust, steel-blue fly, with narrow and not very conspicuous black cross bands at the incisures of the abdominal segments. In the male the eyes are very closely approximated and are not divided into an upper zone of larger and a lower zone of smaller facets; the parafrontals and parafacials are grayish yellow; the clypeus and cheeks are dark yellow. In the female the frontalia are reddish brown and a little narrower at the ends than in the middle; the parafrontals and parafacials are yellowish gray throughout but darker at the vertex. Length, about 12 mm. Larva: The larva is smooth, robust, and cream-colored. The posterior spiracles are separated by about half their greatest diameter; the peritreme is moderately thick; the slits are straight and very wide.

Geographical Distribution.—Australian Region: Western Australia, Queensland, Canberra, New South Wales.

**Pathogenesis.**—This species is a common sheep maggot in Australia; its role is secondary in the southern part of its range, although to the north it is said to become a primary invader. It has not yet been recorded in human myiasis.

## The Genus PHORMIA Robineau-Desvoidy

This genus, in the restricted sense, is characterized as follows: The eyes are bare and narrowly separated or contiguous in the male; the arista is plumose to the tip. The mesonotum is convex; the mesothoracic spiracles are elongated, with bright orange hair; the lower squama is bare; the hind coxae lack posterior cilia. There are four to five postsutural dorsocentrals. The wings are hyaline.

### PHORMIA REGINA (Meigen)

The Black Blowfly

Recognition Characters.—Adult: This is a medium-sized fly, usually 7–9 mm. in length but sometimes larger or smaller; the body is blackish green or olivaceous green, the head chiefly black. The orange hair of the mesothoracic spiracle is conspicuous. Larva: The third-stage larva is creamy translucent white, becoming yellow with maturity. The peritreme of the posterior spiracle is moderately broad; the two spiracles are separated from each other by a distance about two-thirds the diameter of a spiracle.

Geographical Distribution.—Throughout the cooler parts of the Holarctic Region; more abundant in the spring and fall. Nearctic Region: Alaska, Northwest Territory, Quebec, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, Georgia, Alabama, Mississippi, Ohio, Indiana, Illinois, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Arkansas, Louisiana, Texas, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico. Palaearctic Region: Ireland, England, France, Netherlands, Italy, Corsica, Germany, Czechoslovakia, Austria, Yugoslavia, Bulgaria, Greece, European Russia, southwest Mongolia. Australian Region: Hawaiian Islands.

**Biology and Pathogenesis.**—The eggs are deposited in agglutinated masses of varying numbers. The larvae are normally saprophagous and breed in large numbers in carcasses of animals. Develop-

ment is rapid, the total period from egg to adult ranging from 10 to 25 days. Cool weather favors development; in the South they become scarce during the hot months, and adults may be found out of doors during the entire winter at least as far north as Iowa. Hibernation apparently takes place in the adult stage.

Although this is one of the species that has been used in maggot treatment of wounds, it not uncommonly invades healthy tissue. It is a common sheep maggot in the Southwest and in certain localities may be more important as such than *Callitroga americana* during the spring and fall months. Cases of traumatic dermal myiasis in man have been recorded; it has also been reported in enteric myiasis, although the record needs substantiation.

## The Genus PROTOPHORMIA Townsend

This is a genus of metallic blackish-green flies of moderate size. The antennae are rather short; the third segment is about twice as long as the second; the arista is plumose on the basal two-thirds, the plumosity being longer above than below. The mesonotum is flattened on the disc behind the suture; the anterior acrosticals are vestigial or absent; there are four to six, usually five, pairs of postsutural dorsocentrals. The mesothoracic spiracle is dark-haired. The lower squama is bare. The posterior coxae are bare behind.

### PROTOPHORMIA TERRAE-NOVAE (Robineau-Desvoidy)

SYNONYMS.—*Phormia terraenovae* Robineau-Desvoidy; *Phormia groenlandica* (Zetterstedt).

RECOGNITION CHARACTERS.—Adult: This is a dark-blue species with a greenish-blue abdomen and black legs. The front in the male is less than one-fifth the head width; the bucca is about one-fourth the eye height in the male and one-third the eye height in the female. Length, usually 8–12 mm. Larva: The third-stage larva is similar to that of *Phormia regina*, from which it may be distinguished by the characters given in the key.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Greenland, Ellesmere Island (Lake Hazen), Alaska, Yukon, Labrador, Newfoundland, New Brunswick, Quebec (north to Ungava Bay), Manitoba, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, Georgia (northern), Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, North Dakota, South Dakota, Kansas, Texas, Montana, Idaho, Colorado, Utah, New Mexico, Arizona, Washington, Oregon, California. Palaearctic Region: Spitzbergen, Iceland, Scotland, England, France, Netherlands, Norway, Sweden, Lapland (Swedish), Denmark, Germany, Czechoslovakia, Austria, Hungary, Rumania, European Russia, Siberia (Tolstoinos).

**Biology and Pathogenesis.**—This is an early-spring species throughout much of the United States; in more northern localities and at higher elevations it may be common during the summer. It is abundant in Arctic regions and has been taken within 550 miles of the North Pole.

There seem to be no records of myiasis in man, but this species may be a serious parasite in animals. In Arctic regions it often attacks wounds in reindeer and may cause the death of that animal. It may produce wound myiasis in sheep and cattle, and it has been considered a primary sheep blowfly in the early part of the season in Scotland.

## The Genus POLLENIA Robineau-Desvoidy

The species of this genus are dull blackish flies, of medium size, and more or less covered with grayish pollen; the thorax, in addition to the pollen, bears a number of yellowish or grayish, soft, crinkly hairs of characteristic appearance. The eyes are narrowly separated in the male, widely so in the female; the antennae are separated by a narrow carina; the arista is plumose almost to the apex. The propleura and prosternum are bare. The abdomen is oval and flattened.

Keys to the species of western Europe are given by Séguy (*135*), and to those of the Oriental Region by Senior White, Aubertin, and Smart (*139*). These authors employ a broader concept than that indicated by the generic diagnosis given here. Only one species, *P. rudis*, is known to occur in North America.

### POLLENIA RUDIS (Fabricius)

The Cluster Fly

Recognition Characters.—Adult: This is a blackish fly with a tesselated abdomen. The parafacials bear short black hairs; the palpi are black; the squamae are bare; the metathoracic spiracle is reddish haired; and the first posterior cell is open. Length, 7–9 mm., sometimes larger. Larva: The mature larva is rather smooth, the spines being small and colorless; the last segment bears eight protuberances, only the anal pair being strong; each anterior spiracle has four apertures at the ends of fingerlike processes; the posterior spiracle has three straight slits, a definite button, and a weakly sclerotized peritreme.

Geographical Distribution.—Nearctic Region: Nova Scotia, Prince Edward Island, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, Georgia, Florida, Tennessee, Ohio, Michigan, Indiana, Illinois, Minnesota, Wisconsin, Iowa, Idaho, Colorado, Utah, Nevada, Washington, Oregon, California. Palearctic Region: Ireland, Scotland, England, Portugal, Spain, France, Netherlands, Switzerland, Italy, Corsica, Sicily, Norway, Finland, Lapland, Denmark, Germany, Czechoslovakia, Austria, Hungary, Rumania, Bulgaria, European Russia (north to Arkhangelsk), Azerbaijan, Azores, Canary Islands, Madeira, Morocco, Tangier, Syria, Siberia (Kongans), Sinkiang, China. Oriental Region: India.

**Biology and Pathogenesis.**—The larvae develop as internal parasites within the bodies of earthworms. The adults enter houses in great numbers during the winter, especially in the more northern parts of their range, and sometimes cause considerable annoyance.

The larvae have been reported as involved in enteric myiasis in man; however, such records need verification before they can be accepted.

**Literature.**—An extended study of the biology and immature stages has been made by Keilin (*65*).

## The Genus AUCHMEROMYIA Brauer and Bergenstamm

This is a genus of medium-sized yellow flies. The eyes are bare and broadly separated in both sexes, the front being about one-fourth the width of the head, a little narrower in the male than in the female. The arista is long-plumose almost to the tip, the hairs being a little shorter below than above. The female has one proclinate fronto-orbital; these are lacking in the male. There are two sternopleurals.

The second abdominal segment is exceptionally long (fig. 36), being twice as long as the third segment in the female and one and one-half times as long in the male.

As used here the genus contains but one species. Some authors, such as Patton and Roubaud, have used it in a broader sense.

### AUCHMEROMYIA LUTEOLA (Fabricius)

The Congo Floor Maggot

(Fig. 36)

RECOGNITION CHARACTERS.—This fly is similar in appearance to *Cordylobia anthropophaga*, but the long second abdominal segment will readily distinguish it, particularly the female. The mesonotum bears two longitudinal black bands, interrupted at the suture; the abdomen is largely blackened on its apical half, though the extent of the color is variable and may be greatly reduced in the male.

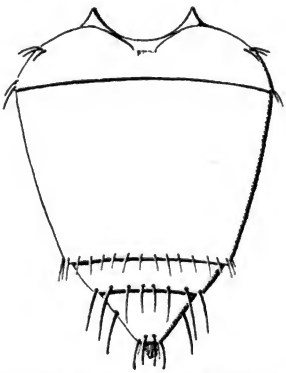

FIGURE 36.—*Auchmeromyia luteola*, outline of abdomen of male, showing the exceptionally long second segment.

Length, 9–13 mm. Larva: The mature larva (fig. 37) is a robust, grublike maggot which is devoid of any noticeable spines. The newly hatched larva is whitish translucent; when engorged with blood it becomes a bright red. The body is much wrinkled and folded longitudinally and transversely. The last segment slopes abruptly at an angle of about 45° from the rest of the body; its dorsal surface (fig. 37, *B*) is flat and bears, near the base, a pair of widely separated spiracles, with short, straight, horizontal slits.

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: French West Africa, Senegal, French Guinea, Sierra Leone, Gabon, Middle Congo, Belgian Congo, Eritrea, Angola, Uganda, Tanganyika, Mozambique, Northern Rhodesia, Natal, Cape of Good Hope.

**Biology and Pathogenesis.**—The adult is a shade-loving fly frequently found in and near human habitations. It feeds on fallen fruits, excrement, fermented vegetable matter, and so forth. Eggs are deposited on dry dusty soil or sand in shaded places. In localities where natives build huts with mud floors, oviposition is frequently made in the dust in the cracks of the floor. About 54 eggs are deposited

in the first batch; at least a second deposition may be made. The newly hatched larva conceals itself in the sand or dust of cracks or under the sleeping mats of African natives; at night it attaches itself to the skin of the sleeper and sucks his blood. According to Roubaud, it is absolutely specific to man and is adapted in its habits to the native blacks, who sleep on the floor; it is unable to reach a cot elevated as little as 10 centimeters from the ground. There are three larval instars; the duration of the larval stage is about 2 weeks under ideal conditions of nourishment, although the larva is capable of withstanding a fast of a month or more, and under conditions of prolonged or intermittent fasting the life cycle is greatly lengthened.

An attack by these bloodsucking larvae cannot be considered myiasis in the proper sense, though it represents a related phenomenon. The larvae of *Auchmeromyia* are the only larvae to suck the blood of man, although species of closely related genera prey in a similar fashion on African Suidae and Edentates, and other Calliphoridae and Muscidae similarly attack nesting birds.

*Auchmeromyia luteola* should be considered a nuisance which will disappear with the advent of civilization. The bite is not painful, and the natives do not seem to mind it; there are apparently no pathogenic complications.

For an extended treatment of the taxonomy and biology of this fly, see Roubaud (*126*). Patton (*106*) discusses the taxonomy and gives a key to *Auchmeromyia* in the broader sense.


FIGURE 37.—*Auchmeromyia luteola*: *A*, Third-stage larva, *B*, dorsal view of last segment of third-stage larva. (After Roubaud (*126*).)

## The Genus CORDYLOBIA Grünberg

This is a genus of yellowish, nonmetallic flies of medium size. The haustellum is short and a little swollen, the palpi are gently clavate, and the arista scantily plumose on about the basal two-thirds, the cilia being shorter below. The eyes are narrowly separated in the male; the vertex of the female is about one-fourth the head width, the front is nearly parallel-sided, and proclinate fronto-orbitals are present. There are three pairs of presutural acrosticals and two sternopleurals. Vein $r_{4+5}$ is ciliated as a rule somewhat less than halfway to cross vein *r-m*.

As used here, the genus is restricted to one known species.

## CORDYLOBIA ANTHROPOPHAGA Grünberg

The Tumbu Fly; Ver du Cayor

(Fig. 38)

SYNONYMY.—Infestation by this species has been erroneously recorded in some earlier literature as due to *Bengalia depressa* (Walker); the true *B. depressa*, however, is quite another fly.

RECOGNITION CHARACTERS.—Adult: This is a yellow fly with two blackish longitudinal bands on the mesonotum and with the apices of the abdominal segments more or less extensively darkened; these markings are somewhat obscured by the grayish pollen that covers them. Length, usually 8–10 mm., sometimes smaller. Larva: The mature larva (fig. 39, *A*) is a robust, grublike yellowish-white maggot, bluntly pointed anteriorly and truncate behind. The segments of the body are transversely wrinkled on the dorsal and ventral sides, especially the

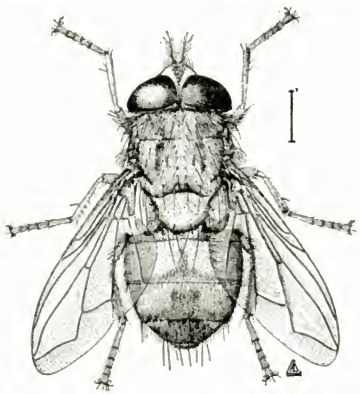

FIGURE 38.—*Cordylobia anthropophaga*, adult male.

latter, and are puckered laterally; the third to eleventh segments are densely covered with small spines usually arranged in transverse series in groups of three or more. The posterior spiracle (fig. 40, *B*) lacks a sclerotized peritreme; the slits are moderately sinuous; the button is present. Length of mature larva, about 12 mm.; greatest width, about 5 mm.

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: French Sudan, Senegal, Niger, French Guinea, Sierra Leone, Ivory Coast, Gold Coast, Dahomey, Nigeria, Chad, Cameroun, Gabon, Anglo-Egyptian Sudan, Italian Somaliland, Belgian Congo, Uganda, Kenya, Tanganyika, Zanzibar, Nyasaland, Mozambique, Northern and Southern Rhodesia, South-West Africa, Transvaal, Natal.

**Biology and Pathogenesis.**—Adults are frequently found indoors. The eggs are deposited on soil or sand fouled with urine or with the excrement of animals, on cloth, soiled bedding, and so forth. Each female may produce 500 eggs or more. After about 2 days the larvae hatch, penetrate the skin of the host if a suitable one can be contacted in time, and thus form boillike tumors in the dermis. The usual three larval instars are passed within the tumor and, about 8 to 9 days after entering the body of the host, the mature larva leaves it and enters the soil. After a prepupal period of about 2 days, pupation takes

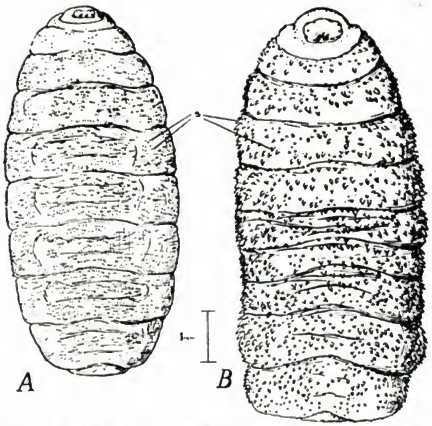


FIGURE 39.—Comparison of third-stage larvae, ventral view: *A*, *Cordylobia anthropophaga*; *B*, *Stasisia rodhaini*. (After Bertram (*14*).)

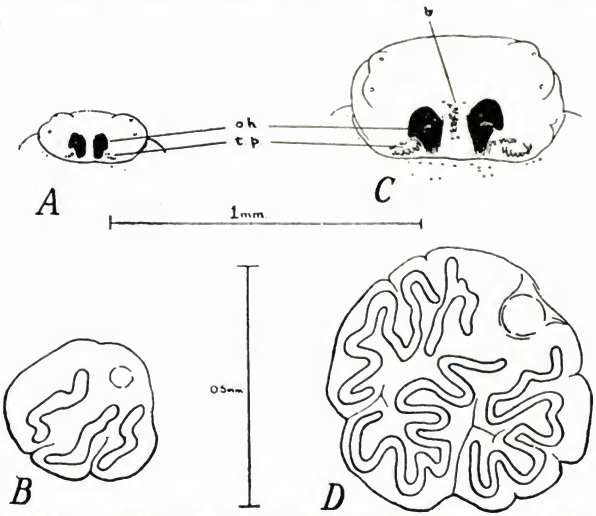


FIGURE 40.—*A*, Cephalic segment of larva, ventral view, of *Cordylobia anthropophaga*; *B*, left posterior spiracle of same; *C*, cephalic segment of larvae, ventral view, of *Stasisia rodhaini*; *D*, left posterior spiracle of same. (After Bertram (*14*).)

place. The period from egg deposition to emergence of the adult is 22 to 24 days.

Rats seem to be the normal host and probably form the reservoir of the parasite in nature. Heavy infestations in that animal may be fatal. Dogs are often severely parasitized, sometimes so much so that death will result. Man is a common host. The young larva usually enters the skin of man without making itself felt. As it develops a red papule forms which ultimately develops into a boil, open at the apex and disclosing the larva which appears like a core. At this time the pain may be so great as to interfere with sleep. No great quantity of pus is formed, but much serous fluid may exude at times when the larva is feeding. The skin is indurated, and the area around the tumor is tender to pressure; the cavity is out of proportion to the size of the larva. After the removal of the larva the symptoms disappear and healing is rapid. In the case of an infection, however, particularly when the larva dies within the cavity, the tumor may become a purulent abscess.

The larva may be expelled by gentle pressure, but that is often painful. The application of a thin film of liquid paraffin will force the larva to back out in an attempt to get oxygen; if the film is gradually thickened, the larva will entangle its posterior end in the paraffin, so that removal may be made much easier. Prophylactic measures are based on the principles of elementary hygiene. Washing and ironing bedding and underclothes exposed to the air will destroy eggs and young larvae that are highly sensitive to heat. Rats should be exterminated, and domestic animals kept free from the pest. Latrines should be kept flyproof, and sand kept in outdoor latrines should be sterilized. It is possible for both man and animals to develop a certain degree of immunity.

**Literature.**—Two important works that treat the biology and pathogenesis at length, with descriptions of the various stages of the fly, are by Roubaud (*126*), and Blacklock and Thompson (*19*); for a more recent study of the larva, see Bertram (*14*).

## The Genus STASISIA Surcouf

This is a genus of flies similar in appearance to *Cordylobia*. The haustellum is stout; the palpi flattened and widened, more so in the female than in the male; and the arista is thinly plumose on about the basal three-fourths, the hairs above being longer than those below. The front is almost parallel-sided in both sexes and almost one-fourth the width of the head. Proclinate fronto-orbital, ocellar, and outer vertical bristles are lacking in both sexes. There are three presutural acrosticals and two sternopleurals. Vein $r_{3+4}$ is ciliated about halfway to cross vein *r-m*; there is no costal spine.

There is but one known species.

### STASISIA RODHAINI (Gedoelst)

The Larva of Lund

SYNONYM.—*Cordylobia rodhaini* Gedoelst.

RECOGNITION CHARACTERS.—Adult: This is a yellowish fly with the abdomen chiefly shining black or brown. Larva: The mature larva (fig. 39, *B*) is a robust grub about 17–33 mm. in length by 8 mm. in maximum width. The body is strewn, dorsally and ventrally, with sparse but large spines; those on the last two segments, however, are few and very small. The last body segment is retracted

into the penultimate one; the posterior spiracle (fig. 40, *B*) is without a sclerotized peritreme, and its slits are long and serpentine, at least one of them usually being fragmented into two parts.

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: Niger, Senegal, Gold Coast, Cameroons, Gabon, Middle Congo, Belgian Congo, Angola, Kenya, Southern Rhodesia.

**Biology and Pathogenesis.**—The adult fly inhabits wet tropical forests and is crepuscular. It feeds on fruits, sweet juices, excrement, etc.; it may live 6 weeks or more. Eggs are deposited on soil or in places where the host is likely to rest. The number of eggs produced by a female in her lifetime may exceed 500. The eggs hatch in 2 to 4 days, and the young larva then penetrates the integument of the host while the latter is at rest. The larva finally comes to rest in a tumor formed under the skin. There are the usual three larval instars. The larval stage normally lasts about 12 to 15 days; the pupal stage, which is passed in the soil, lasts 23 to 26 days. The normal hosts seem to be African antelopes (*Cephalophus*) and rodents (*Cricetomys*).

Domestic animals seem not to be affected, and man is an abnormal host, although occasionally he is infested. The tumors are similar to those of *Cordylobia anthropophaga*, though larger and more painful. No great quantity of pus is formed. The duration of parasitism is the 12 to 15 days of the larval life of the parasite although it may penetrate the skin unnoticed, where its presence may not be detected for 2 or 3 days.

**Literature.**—A detailed discussion of this species, with its biology, pathogenesis, and descriptions of immature and adult stages, is given by Rodhain and Bequaert (*122*); for a more recent study of the larva, see Bertram (*14*).

### The Genus LUCILIA Robineau-Desvoidy

### (including PHAENICIA Robineau-Desvoidy)

The Green-bottle Flies

The species treated here have been referred to *Lucilia* by most authors; but recently Hall (*49*) has followed Townsend in recognizing several generic segregates. Though it is probable that the more restricted generic treatment will ultimately be adopted, these two genera are here treated together for the sake of convenience.

The genus *Lucilia*, in the broader sense, includes a number of species of metallic flies, usually green or bluish green, of medium size. The following characters are common to the species of *Lucilia* and *Phaenicia* treated here: The parafacials and parafrontals are largely covered with silvery or golden pollen, though the parafacials lack pile; the eyes are bare; the arista is long-plumose almost to the apex. The mesonotum is convex; the propleura and both squamae are bare. The wings are hyaline; vein $r_{4+5}$ is ciliated almost to cross vein *r–m*. The abdomen lacks discal bristles except on the anal segment, and the marginal bristles on the intermediate segments are small and inconspicuous.

**Pathogenesis.**—Most species of *Lucilia* and *Phaenicia* are saprophytic. However, in *P. sericata* (Mg.) and *P. cuprina* (Wd.) the parasitic habit has developed to a serious extent, these species being important sheep maggots and occasionally attacking man. As parasites

of lower vertebrates, *Bufolucilia silvarum* (Mg.) and *B. bufonivora* (Mon.) often produce a fatal myiasis in Amphibia.

**Larva.**—The larva is similar to that of *Calliphora*, but is usually smaller; it lacks the accessory oral sclerite characteristic of that genus.

**Literature.**—In addition to general works on the subject, there is a review of the world species of *Lucilia* in the broad sense by Aubertin (*4*).

### KEY TO SPECIES

1. Subcostal sclerite with wiry bristlelike setulae; basicostal scale black; postsutural acrosticals ..... 2
   Subcostal sclerite with only soft pubescence; basicostal scale yellow; postsutural acrosticals ..... 3
2. Male with frontalia nearly obsolete at the narrowest part, the eyes being nearly contiguous for a short distance; male hypopygium large and metallic; Palaearctic species ..... *Lucilia caesar* (Linnaeus)
   Male with frontalia evident throughout and nearly as wide as the parafrontal at the lunule; male hypopygium small; Holarctic species ..... *Lucilia illustris* (Meigen)
3. Male with 2 pairs of ocellar bristles, that is, a second and shorter pair just behind or on a level with the posterior ocelli; front of male about one-fifth head width; abdominal sternites of male long haired; bucca of female less than one-third eye height ..... 4
   Male without the accessory pair of ocellars; front of male about one-eighth head width; sternites of male with ordinary pile; bucca of female almost two-fifths eye height ..... *Phaenicia sericata* (Meigen)
4. Old World species ..... *Phaenicia cuprina* (Wiedemann)
   New World species ..... *Phaenicia pallescens* (Shannon)[5]

### LUCILIA CAESAR (Linnaeus)

Recognition Characters.—This is a bluish-green species with hyaline wings, stiff black setulae on the subcostal sclerite, and two postsutural acrosticals; the females are difficult to separate from some other species of *Lucilia*, but the male may be recognized by the very prominent shining green hypopygium. Length, 5–10 mm. Larva: The posterior spiracles of the mature larva are somewhat pear-shaped, with a very thin peritreme and three straight, rather slender slits; the spiracles are distant from each other by a little less than the diameter of one of them.

Geographical Distribution.—Palaearctic Region: Ireland, Scotland, England, Isle of Wight, Spain, France, Netherlands, Switzerland, Italy, Sardinia, Sicily, Germany, Austria, Poland, Czechoslovakia, Hungary, Yugoslavia, Rumania, Bulgaria, Greece, European Russia (north to Moscow), Azerbaijan, Canary Islands, Madeira, Morocco, Libia, Siberia (Ussuri, Kamchatka), China, Manchuria, Japan. The species has been reported from many other parts of the world, but probably all except the Palaearctic records are erroneous.

**Biology and Pathogenesis.**—The larva is primarily saprophagous and usually breeds in decaying animal matter. It has, however, been recorded as a secondary sheep maggot in the British Isles, and Séguy (*135*) reports it as attacking a wounded hedgehog. Cases of human wound myiasis are reported by Onorato (*96*) in Libia and by Galli-Valerio (*43*) in Switzerland; if the identifications are correct, this species can produce a severe, though rare, myiasis, which in one instance required the amputation of a hand. Auricular and gastrointestinal myiases have also been attributed to this species.

The literature on this species is abundant, but much of it is based on mistaken identifications. This is especially true of the non-European

[5] This species has been included in the key because it has been confused in literature with *P. cuprina*. The differentiation between these species is mainly one of relative measurements; biologically, however, *P. pallescens* seems to be purely saprophytic.

literature. Consequently, statements concerning the biology and the role as a parasite must depend upon the correctness of the identifications.

### LUCILIA ILLUSTRIS (Meigen)

SYNONYMY.—This species has been confused with *L. caesar*, and much of the literature in the name of that species really refers to *illustris*.

RECOGNITION CHARACTERS.—Adult: This is a bluish-green species; the wings are hyaline; there are two pairs of postsutural acrostichals, the anterior pair being farther forward than the middle pair of postsutural dorsocentrals. The females are difficult to distinguish from *L. caesar*, but the males have a smaller hypopygium which is not so strongly shining, and the anterior forceps are simple at the end. The frontalia in the male are evident for their entire length, or at most only briefly evanescent. Length, 6–9 mm. Larva: The mature larva has a heavily pigmented area below the posterior end of the ventral horn of the cephalopharyngeal skeleton; the posterior spiracles are comparatively large and heavily pigmented; the peritreme is prominent, with well developed inward projections between the outer and middle slits.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alaska, Yukon, Prince Edward Island, New Brunswick, Quebec, Ontario, Saskatchewan, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, North Carolina, Georgia, Mississippi, Ohio, Michigan, Indiana, Minnesota, Wisconsin, Iowa, Missouri, South Dakota, Kansas, Texas, Montana, Idaho, Colorado, Utah, New Mexico, Washington, Oregon, California. Neotropical Region: Mexico. Palaearctic Region: Scotland, England, France, Netherlands, Belgium, Sweden, Germany, Czechoslovakia, Rumania, Bulgaria, Russia (north to Moscow), China, Manchuria, Japan. Oriental Region: India, Burma. Australian Region: Queensland, New Zealand.

**Biology and Pathogenesis.**—The larva is sometimes found in excrement and garbage, but it most frequently occurs in carrion. It is normally a scavenger, but, if the identifications are correct, it occasionally becomes parasitic. Hall (*49*) cites Kingscote's report of larvae of this species killing young foxes by a subdermal myiasis. Human cases reported include myiasis of an open wound in the leg of a man in Saskatchewan, Canada, and myiasis of an ulcer on the side of the head of a man in Philadelphia.

### PHAENICIA CUPRINA (Wiedemann)

SYNONYMS.—*Lucilia cuprina* (Wiedemann); *Lucilia argyricephala* Macquart. Some records of *Phaenicia sericata* belong to this species.

RECOGNITION CHARACTERS.—Adult: This is a metallic-green fly, usually with coppery reflections, although a bright-green phase may occur in widely separated parts of its range. The parafrontals of the female may be bare on the lower half or may have five scattered hairs in not more than two irregular rows. On the abdominal sternites of the male are tufts of hair which are much longer than that of the rest of the abdomen. There is one anterodorsal bristle on the middle tibia. Length, 6–8 mm. Larva: The larva, according to Fuller (*51, p. 82*) is similar to that of *L. sericata*; the antennae are much less obvious, and the posterior spiracles differ in having a thicker peritreme, shorter and broader slits, and a more rounded shape.

GEOGRAPHICAL DISTRIBUTION.—Oriental Region: India, Chagos Islands, Singapore, Burma, French Indochina, Sumatra, Timor. Ethioplan Region: French Guinea, Italian Somaliland, Belgian Congo, Uganda, Kenya, Southern Rhodesia, Cape of Good Hope, Madagascar, Seychelles, Mauritius, Cargadoes Islands. Australian Region: Western Australia, Queensland, Canberra, New South Wales, Victoria, New Hebrides, Fiji, Hawaiian Islands.

**Biology and Pathogenesis.**—This species is primarily a scavenger, although in some parts of the world, notably Australia, the parasitic habit has become strongly developed. The eggs hatch within a day's

time under usual conditions. The larva feeds for 4 to 6 days; after a resting and wandering period, which may vary considerably with the seasons, it enters the ground to pupate. The pupal period, under summer conditions in Australia, lasts about a week. The life cycle, from egg to adult, takes about 2 weeks; another week to 10 days must elapse before the female is ready to oviposit.

This is the most serious of the Australian sheep maggots, and may be the only one involved in such a role in the winter months. It is known to oviposit in wounds of other animals in other parts of its range. Several records of wound myiasis in man from various parts of Africa have been published.

## PHAENICIA SERICATA (Meigen)

The Green-Bottle Fly; the English Sheep Fly

SYNONYM.—*Lucilia sericata* (Meigen).

RECOGNITION CHARACTERS.—Adult: This is a metallic-green fly, often with yellowish or coppery reflections; the genae are exceptionally wide, being about

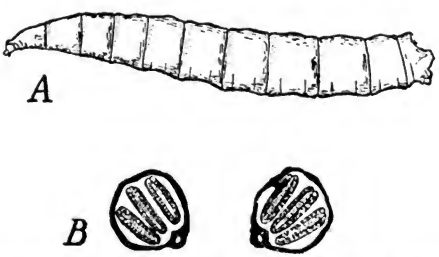


FIGURE 41.—*Phaenicia sericata: A*, Larva; *B*, posterior spiracles or larva. (After Smit (*143, p. 369*).)

one-third the head height in the male and two-fifths the head height in the female; the front of the male, at its narrowest, is about one-eighth to one-ninth the head width. The parafrontals of the female bear a number of scattered setulae in several irregular rows. Length, 6–9.5 mm. Larva (fig. 41, *A*): The mature larva is about 14 mm. in length, slender and cylindrical, and deep cream tinged with pinkish or purple. The spines are very small. The posterior spiracles (fig. 41, *B*) are pear-shaped; the peritreme is thinner and the slits longer and more slender than in *P. cuprina*.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alaska, Yukon, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Ohio, Michigan, Indiana, Illinois, Minnesota, Wisconsin, Iowa, South Dakota, Kansas, Louisiana, Texas, Montana, Idaho, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico, Guatemala, Bermuda, Paraguay, Argentina. Palaearctic Region: Ireland, Scotland, Wales, England, Portugal, Spain, France, Netherlands, Belgium, Italy, Corsica, Sardinia, Sicily, Sweden, Denmark, Germany, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, Bulgaria, Greece, European Russia (southern half to Moscow), Azerbaijan, Azores, Canary Islands, Madeira, Morocco, Tangier, Algeria, Tunisia, Libia, Egypt, Turkey, Levant States, Dodecanese, Arabia, Iraq, Iran, Southwest Mongolia, China, Japan. Oriental Region: India (North-West Province), Ceylon. Ethiopian Region: Gold Coast, Eritrea, Ethiopia, Italian Somaliland, Angola, Kenya, Mozambique, Northern and Southern Rhodesia, South-West Africa, Transvaal, Natal, Orange Free State, Cape

of Good Hope. Australian Region: Western Australia, South Australia, Queensland, Canberra, New South Wales, Victoria, New Zealand, New Hebrides (Espiritu Santo Island), Wake Island, Hawaiian Islands.

**Biology and Pathogenesis.**—The female deposits her eggs in a mass on or near the food substance. Sometimes two or more females may produce composite masses on the same wound, and such aggregate masses may contain thousands of eggs. The larva undergoes three molts; after a feeding period of 1½ to 9½ days, it seeks a favorable place in the soil to pupate. Development is more rapid under warmer conditions, and under unfavorable circumstances pupation may be suspended for months. Probably as many as eight annual generations may occur in localities where breeding is continuous throughout the year. Hibernation takes place chiefly in the larval stage.

The common breeding medium is carrion, although larvae have been reared from manure and from garbage. This species is frequently attracted to ill-smelling sores and soiled wool, and is one of the principal sheep-maggot flies in the British Isles, South Africa, and New Zealand. It has also been known to attack man in Europe, Africa, and Asia, and may produce a serious form of wound myiasis. The young larvae feed near the surface, but older larvae may bore deeply into healthy tissue. Onorato (*96*) records cases of infestation of the ear and sinuses which were not previously diseased. Other cases of auricular myiasis have been recorded. The virulence of different strains varies. A Chinese strain is said to be particularly serious, whereas in America this species seems to confine its attacks to diseased tissue; in fact, it is the species most commonly used in wound therapy. Records of this species in enteric myiasis have been published, but they should not be accepted without further substantiation.

The literature on this species is voluminous.

## The Genus CYNOMYOPSIS Townsend

This is a genus of moderately large, metallic-blue flies. The eyes are bare; there is no facial carina; the parafacials are setose on the upper part; the arista is long haired above and below as far as the apical third or fourth, the cilia, however, being somewhat shorter below than above; the male lacks reclinate fronto-orbitals. The lower squama is rather wide, pilose above, and truncate posteriorly; there are two postsutural acrosticals and three lateroscutellars.

### CYNOMYOPSIS CADAVERINA (Robineau-Desvoidy)

Synonym.—*Cynomya* (or *Cynomyia*) *cadaverina* Robineau-Desvoidy.

Recognition Characters.—Adult: The head is black above, covered with dense silvery to brownish pollen; the face and anterior parts of the cheeks are yellowish to reddish brown; the thorax is bluish black; the abdomen is shining blue green, with pollen visible only from behind. Length, 9–14 mm. Larva: In the mature larva the anterior spiracle terminates in 7 to 10, usually 8, fingerlike processes; the posterior spiracle is somewhat pear-shaped, with a moderately thick peritreme.

Geographical Distribution.—Nearctic Region: Greenland, Alaska, Yukon, Northwest Territories (Baffin Island, Southampton Island), Labrador, New Brunswick, Quebec (north to Akpatok Island in Ungava Bay), Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, Georgia, Louisiana, Ohio, Michigan, Indiana, Illinois, Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Kansas, Oklahoma, Texas, Montana, Idaho, Colo-

rado, Arizona, Washington, Oregon, California. Palaearctic Region: "Northern Europe" (Enderlein).

**Biology and Pathogenesis.**—The larvae normally breed in carrion. As many as 25 to 50 eggs may be deposited at a time, although the number is usually smaller. In the warmer parts of its range the adults appear in early spring and late autumn; they may enter houses in considerable numbers at such times. They are attracted to carrion in an advanced stage of decomposition.

A number of cases of wound myiasis in man and other warm-blooded animals have been reported, but the role of this fly seems to be that of a secondary invader in old and pustular lesions and consequently of little importance in destroying tissue.

### The Genus CALLIPHORA Robineau-Desvoidy and Related Genera

The genus *Calliphora*, broadly viewed, is of world-wide distribution and includes the well-known larger blowflies or bluebottle flies. In the Australian Region this group is well represented, and several of the species are important sheep maggots. Townsend has restricted the genus to *C. vomitoria* and its relatives. Certain workers on the Australian fauna have adopted several of his restricted groups in a subgeneric sense, and, with the present tendency, these will probably be considered valid genera by many students in the near future.

The genera gronped together under this heading agree in the following characters: The facial carina is vestigial or lacking; the eyes are bare (except in *C. quadrimaculata*); the mesonotum behind the suture is not flattened on the disc; the lower squama is pilose above; the wings are hyaline, without definite clouded bands or areas; and the remigium is bare above. Certain other genera, such as *Cynomyopsis*, also possess this combination of characters, but the key to species and restricted genera will exclude them.

**Pathogenesis.**—Three species of *Calliphora* (in the strict sense) have been recorded in human myiasis. The other species treated here, in the genera *Adichosiops*, *Neopollenia*, and *Anastellorhina*, are Australian sheep maggots which have not been reported in human myiasis but may conceivably become so involved. Their inclusion here is justifiable only on this suspicion; reference to the Australian sheep-maggot literature will yield much information on their biologies.

**Literature.**—The amount of taxonomic literature on this genus is great; the following will be useful: For the North American species, Hall (*49*); for the Australian species, Hardy (*54*); for the adults and larvae of the New Zealand species, Miller (*90*); and for the larvae of the Australian species, Fuller (*41, p. 78*). A large amount of literature on the Australian sheep-maggot problem is available; an important bulletin on this subject is the report of the Joint Blowfly Committee (Tillyard and Seddon, *148*).

**Life Histories.**—Normally the blowflies, such as those belonging to *Cynomyopsis* and related genera, are scavengers feeding on decaying animal matter; sometimes they invade the diseased tissue of wounds or adjacent healthy tissue, and rarely other breeding media are chosen. The adult flies may be attracted to flowers, feces, overripe fruits and other decaying vegetable matter, fresh or tainted meat, and sores of living animals. The females are oviparous. Development is usually rapid, the third larval stage often being attained on the second or third day after hatching.

**Larva.**—In the third-stage larva the posterior spiracles have a complete peritreme, within which the button is situated, and accessory oral hooks are present (fig. 6, *C*).

## KEY TO RESTRICTED GENERA AND SPECIES

1. Eyes distinctly pilose; parafacials bare on lower half; about 6 laterocentellars (*Adichosiops*) ..... *quadrimaculata* (Swederus)
   Eyes bare ..... 2
2. Abdomen olivaceous marmorate and not metallic; anal segment and venter with stiff pale hair (*Neopollenia*) ..... 3
   Abdomen metallic green, bluish, or violet, at least in the middle ..... 7
3. Male with the upper eye facets much larger than the lower and with the eyes almost contiguous; female front very wide, much wider than long ..... 4
   Male with the upper and lower eye facets not strongly contrasting in size; female front about as wide as long ..... 5
4. Australian species ..... *stygia* (Fabricius)
   New Zealand species ..... *lucnica* (White)
5. Three pairs of presutural acrosticals, the hind pair being very near to the suture ..... *australis* (Boisduval)
   Two pairs of presutural acrosticals, the hind pair being remote from the suture ..... 6
6. Eyes of male separated by the width of the ocellar triangle; frons of female broader than long (ratio, 26:20); frontal orbits with a strongly silvery sheen ..... *rufipes* (Macquart)
   Eyes of male separated by twice the width of an ocellus; frons of female as long as broad; frontal orbits with a golden sheen ..... *fallax* (Hardy)
7. Abdomen yellow on the base, sides, and venter, less so on anal segment; epistoma strongly warped; legs mainly yellow (*Anastellorhina*) ..... 8
   Abdomen green, bluish, or violet, without yellow areas; epistoma not so strongly warped; legs wholly black; arista plumose practically to the tip; 3 sternopleurals; frontals stopping practically at the bases of the antennae; scutellum with 4 or more strong lateral bristles. (*Calliphora*) ..... 9
8. Abdominal stripe blue-green, with yellow pollen on the fourth tergite ..... *augur* (Fabricius)
   Abdominal stripe vivid blue, with white pollen on the fourth tergite ..... *nociva* (Hardy)
9. Bucca reddish on anterior half or more; basicosta often yellow to yellow-orange ..... *vicina* Robineau-Desvoidy
   Bucca entirely black, the facial grooves, however, yellow to orange ..... 10
10. All hairs of bucca black; basicosta silvery ..... *croceipalpis* Jaennicke
    The longer hairs on the posterior part of the bucca orange; basicosta black ..... *vomitoria* (Linnaeus)

### ADICHOSIOPS QUADRIMACULATA (Swederus)

SYNONYM.—*Calliphora quadrimaculata* (Swederus).

GEOGRAPHICAL DISTRIBUTION.—Australian Region; New Zealand, Auckland Islands, Campbell Island.

**Pathogenesis.**—This is a sheep maggot of minor importance in New Zealand. It is extremely common in human dwellings.

### NEOPOLLENIA STYGIA (Fabricius)

The Large Brown Blowfly; the Golden-haired Blowfly

SYNONYM.—*Calliphora stygia* (Fabricius).

GEOGRAPHICAL DISTRIBUTION.—Australian Region; Western Australia, South Australia, Queensland, New South Wales, Canberra, Victoria, Tasmania.

**Pathogenesis.**—This is one of the more important sheep maggots in Australia and is a primary parasite.

### NEOPOLLENIA LAEMICA (White)

SYNONYM.—*Calliphora laemica* (White).
GEOGRAPHICAL DISTRIBUTION.—Australian Region: New Zealand and adjacent islands.

**Pathogenesis.**—This is one of the two most important sheep maggots in New Zealand and is a primary parasite. During warmer weather it is larviparous, though at other times oviparous. It occurs commonly in houses.

### NEOPOLLENIA AUSTRALIS (Boisduval)

The Western Australian Brown Blowfly

SYNONYM.—*Calliphora australis* (Boisduval).
GEOGRAPHICAL DISTRIBUTION.—Australian Region: Western Australia.

**Pathogenesis.**—This is an important sheep maggot and a primary parasite in Western Australia, where it replaces *N. stygia*.

### NEOPOLLENIA RUFIPES (Macquart)

SYNONYMS.—*Calliphora rufipes* (Macquart 1835); *Calliphora hilli* Patton.
GEOGRAPHICAL DISTRIBUTION.—Australian Region: South Australia, New South Wales, Victoria, Tasmania, New Zealand. It is said to be a coastal species in Australia.

**Pathogenesis.**—This is a sheep maggot of minor importance.

### NEOPOLLENIA FALLAX (Hardy)

SYNONYM.—*Calliphora fallax* Hardy.
GEOGRAPHICAL DISTRIBUTION.—Australian Region: Canberra, Queensland.

**Pathogenesis.**—This is a sheep maggot of minor importance; however, at times it may be a primary parasite.

### ANASTELLORHINA AUGUR (Fabricius)

The Lesser Brown Blowfly

SYNONYM.—*Calliphora augur* (Fabricius).
GEOGRAPHICAL DISTRIBUTION.—Australian Region: Western Australia, South Australia, Queensland, New South Wales, Canberra, Victoria, Tasmania, New Caledonia, Timor, New Guinea.

**Pathogenesis.**—This is one of the more important sheep maggots in Australia and is a primary parasite.

### ANASTELLORHINA NOCIVA (Hardy)

SYNONYM.—*Calliphora nociva* Hardy.
GEOGRAPHICAL DISTRIBUTION.—Australian Region: Western Australia, South Australia, Queensland, New South Wales, Canberra, Victoria.

**Pathogenesis.**—This is a sheep maggot of minor importance in Australia.

### CALLIPHORA VICINA Robineau-Desvoidy

The European Bluebottle Fly

SYNONYM.—*Calliphora erythrocephala* (Meigen).
RECOGNITION CHARACTERS.—Adult: This is a robust fly, usually measuring 9–11 mm. in length. The head is black above, the anterior half or more of the bucca and the lower part of the facials being reddish yellow; the front of the

female is about one-third, that of the male about one-tenth, the width of the head. The thorax is black, its dorsum with dense grayish pollen; there are two postsutural intra-alars; the scutellum bears at least four pairs of strong lateral bristles. The abdomen is blue with silvery tessellation. Larva: The mature larva is about 17 mm. in length and whitish to yellowish. Segments 2 to 9 have complete anterior spinulose bands. The anterior spiracles end in 7 to 9 processes; the posterior spiracular plates are subcircular and are separated by approximately the diameter of one plate; the peritreme is broad and is completely sclerotized; its inner outline between the slits is distinctly scalloped.

Geographical Distribution.—Widespread throughout the temperate parts of the world. Nearctic Region: Greenland, Alaska, New Brunswick, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Ohio, Indiana, Minnesota, Wisconsin, Iowa, Missouri, South Dakota, Nebraska, Kansas, Arkansas, Louisiana, Oklahoma, Texas, Montana, Idaho, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico (south to Mexico City), Chile, Argentina, Patagonia, Tierra del Fuego, Falkland Islands. Palaearctic Region: Spitzbergen, Iceland, Ireland, Scotland, England, Spain, France, Netherlands, Italy, Corsica, Sardinia, Sicily, Malta, Norway, Sweden, Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Rumania, Bulgaria, European Russia (north to Arkhangelsk), Azerbaijan, Azores, Canary Islands, Madeira, Morocco, Tangier, Tunisia, Libia, Egypt, Levant States, Dodecanese, Syria, Iraq, Iran, Commander Island, China, Japan. Oriental Region: India (northern mountainous parts). Ethiopian Region: Cape of Good Hope. Australian Region: South Australia, New South Wales, Victoria, Tasmania, New Zealand.

**Biology and Pathogenesis.**—Eggs are deposited on the breeding medium, where they hatch in a day's time or less. A female may deposit as many as 180 eggs at a time, though she usually deposits fewer; she may produce from 540 to 720 eggs in her lifetime. The larva grows rapidly; under favorable conditions it is ready to pupate in about a week after oviposition. It then leaves the breeding medium and burrows into the soil, where pupation takes place, the pupal state, in the summertime, lasting from a week to 10 days. With allowance made for the preoviposition stage, a complete generation requires 30 to 40 days in summer. The adults occur commonly in houses during the cooler seasons and may remain active until November in north temperate latitudes. Hibernation probably occurs in the pupal stage. The normal breeding medium is carrion; eggs may be deposited on tainted meat.

As a parasite on man it is uncommon, but may at times produce severe myiasis. Entrance is obtained through diseased tissue. Onorato (*96*) cites two cases in the rectal region secondary to ulcers, one in the ear secondary to otitis, and one in the oral cavities secondary to stomatitis. Other cases on record show a preexisting diseased condition of the organ affected. The larvae may burrow deeply into healthy tissues and may be present in numbers up to 100 or more. It has been reported as a secondary sheep maggot of minor importance.

This species has been accused of producing gastrointestinal myiasis, live maggots having been reported on several occasions from stools and vomitus under conditions which would seem to bar the possibility of subsequent infestation. If such records are correct, the larvae or eggs were probably introduced with tainted prepared meats.

### CALLIPHORA CROCEIPALPIS Jaennicke

Recognition Characters.—Adult: The eyes are practically bare, those of the male being very short pubescent; the front of the male is very narrow; the cheeks are black-haired, the hairy parts also being black; the palpi and the

prothoracic spiracle are orange; the abdomen is violet-blue in ground color. Length 8–10 mm.

GEOGRAPHICAL DISTRIBUTION.—Ethiopian Region: Eritrea, Kenya, Tanganyika, South-West Africa, South Africa (Natal, Transvaal, Cape of Good Hope), Saint Paul Island.

**Pathogenesis.**—A case of auricular myiasis has been reported from South Africa, and larvae have been recovered from the stool of a native child, also in South Africa.

### CALLIPHORA VOMITORIA (Linnaeus)

RECOGNITION CHARACTERS.—Adult; This species is similar in appearance to *C. vicina*, from which it may be distinguished by the characters given in the key. The bucca is black, about half the eye height in the male and two-thirds the eye height in the female, and is clothed with reddish-orange hairs; there are three postintra-alar bristles. Length 10–14 mm. Larva: The posterior spiracle is similar to that of *C. vicina*, but the inner margin of the peritreme between the slits is not scalloped.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Greenland, Alaska, Labrador, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, North Carolina, Indiana, Minnesota, Wisconsin, Kansas, Texas, Idaho, Colorado, Utah, New Mexico, Washington, Oregon, California. Neotropical Region: Mexico (highland), Bermuda (?). Palaearctic Region: Ireland, Scotland, England, Portugal, Spain, France, Netherlands, Italy, Corsica, Sicily, Norway, Sweden, Lapland (Swedish), Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Rumania, Bulgaria, European Russia, Azores, Canary Islands, Madeira, Morocco, Libia, China, Japan. Oriental Region: India (northern part), Philippine Islands. Ethiopian Region: Cape of Good Hope, St. Paul, and Amsterdam Islands. Australian Region: Hawaiian Islands. In addition, it has been recorded from various tropical regions and New Zealand, but these records are most probably erroneous.

**Biology and Pathogenesis.**—The life history and habits of this fly are probably similar to those of *C. vicina*. It is primarily a carrion feeder; however, it may be attracted to ill-smelling sores or lesions, or to diseased body openings, in which case the larvae may penetrate deeply into the surrounding tissue. Cases of gastrointestinal myiasis have been reported.

## The Family GASTEROPHILIDAE

This family has been treated by many authors as part of the Oestridae or Larvaevoridae (Tachinidae), on the one hand, and of the Muscidae or Anthomyiidae, on the other. The present treatment conforms with that of Comstock, Curran, Townsend, and other authors who consider the genus *Gasterophilus*, in the broader sense, either alone or together with some genera not of medical importance to man, as having family rank. For the purposes of this work, therefore, the family characters may be considered the same as those of the genus *Gasterophilus*.

### The Genus GASTEROPHILUS Leach

The name of the genus is sometimes incorrectly spelled *Gastrophilus*, as emended by Schiner (*131, p. 390*). Townsend, in his Manual, divides it into four genera—*Gasterophilus* (in the strict sense), *Progastrophilus*, *Haemorrhoestrus*, and *Rhinogastrophilus*.

In these flies the head is short and deep, clothed with conspicuous pile but with the bristles strongly reduced or absent. The antennae

are small, with a bare arista. The mouth parts are greatly reduced and nonfunctional, the fly taking no food as an adult. The thorax is hairy but without well-developed bristles; the wing (fig. 42) has an easily recognizable venation, with the subcosta and the branches of the radius running close to the costal margin, vein $m_{1+2}$ running straight toward the posterior margin or slightly bowed downward but never with an upcurved bend, and vein 1st A reaching the wing margin. The membrane of the wing is crinkly and the microtrichia scarcely evident. The abdomen is elongated-oval, with the apex curved under; in some species the ovipositor is long and strongly recurved beneath the abdomen. The adults in size and appearance bear a strong resemblance to the honeybee, and this resemblance is accentuated by the bee-like buzzing produced by their flight.

**Life Histories.**—The normal hosts are horses and other Equidae. The adult is short-lived and takes no food. The female usually deposits

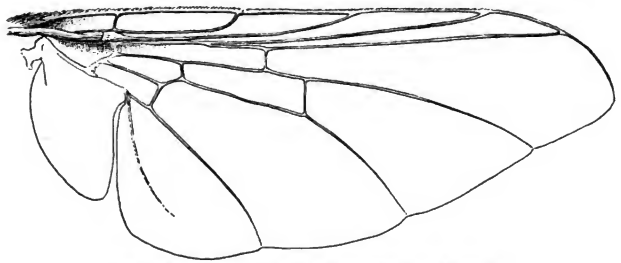

FIGURE 42.—*Gastrophilus haemorrhoidalis*, wing.

eggs singly while in flight upon hairs on the body of the animal, the part of the body chosen being characteristic of the species of fly. The number of eggs produced by each female differs and is correlated somewhat with the chances of survival of the progeny. The first-stage larva, after hatching, makes its way to the mouth of the horse and buries itself in a pocket or tunnel which it forms in the epithelial tissue of the mouth or tongue. Details of the life histories vary with the species, but the parasite always completes its larval development in the stomach or intestine, is passed with the feces, and enters the ground to pupate. The period spent in the digestive tract of the horse ranges from 8 to 11 months.

Man is an accidental host, and in him the larva is almost always incapable of developing beyond the first stage. He may become infested, while around horses, by the fly mistaking him as a suitable host for her progeny, or by his rubbing or petting an animal upon which the fly has oviposited. In man the larva, not finding the proper place in which to burrow and molt, enters the skin and wanders about in search of such a place, thus producing the characteristic symptoms of creeping eruption.

**Larva.**—The first-stage larva (fig. 43) is elongated and fusiform, broadest in front of the middle; it is composed of 13 segments, the first or head segment being short and the thirteenth bearing the

spiracles, which in most species are located on short stalks. Each posterior spiracle has one opening. In the second instar the posterior end broadens in comparison with the anterior, the last segment becomes retracted into the twelfth, and the posterior spiracles, no longer located on processes, possess 2 openings each. The third-stage larva (fig. 44) is robust and much broader behind than at the head end; the head segment is very short; the last segment is as in the second instar, with 3 slits to each spiracle. The length of the larva is about 1 mm. in the first instar, 1.5–7 mm. in the second, and 7–20 mm. in the third.

**Etiology and Pathogenesis.**—Three species—namely, *G. nasalis* (Linnaeus), *G. intestinalis* (Degeer), and *G. haemorrhoidalis* (Linnaeus)—have been accused of causing subcutaneous myiasis in man.

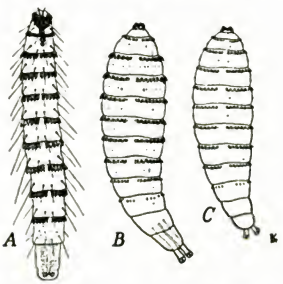


FIGURE 43.—First-stage larva: A, *Gasterophilus nasalis*; B, *G. intestinalis*; C, *G. haemorrhoidalis*. (After Wells and Knipling (*159, p. 201*).)

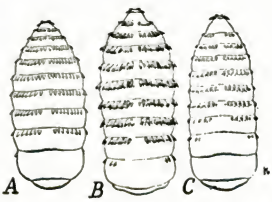


FIGURE 44.—Mature larva: A, *Gasterophilus nasalis*; B, *G. intestinalis*; C, *G. haemorrhoidalis*. (After Wells and Knipling, (*159, p. 203*).)

The first-stage larva bores through the epidermis; the exact location of the tunnels in relation to the layers of skin is variable, but the horny layer usually forms the roof of the tunnel and the epidermis or corium its floor. The tunnels are often serpentine and may cross and recross themselves; they appear as raised red stripes, which advance at one end and gradually fade out at the other. An intense itching sensation is usually felt.

The larva usually advances about 1 to 2 cm. daily, the progress generally being more rapid at night. This infestation may end spontaneously or at times by suppuration.

The disease is known by various names, such as creeping eruption, creeping disease, larva migrans, myiasis linearis, rampant subcutaneous myiasis, hyponoderma, Hautmaulwurf (in Germany), and volassatik (in Russia). All cases of creeping disease are not produced by *Gasterophilus*, however; they may be due to *Hypoderma* or to nematodes, and in some types of cases the etiological agent is unknown.

Stomach parasitism may occur in animals other than the horse; such

accidental hosts include dogs, hyenas, rabbits, and crows. At least two cases are on record of larvae of an unidentified species of *Gasterophilus* infesting the digestive tract of man and producing distressing symptoms.

For a case of ophthalmomyiasis see *Gasterophilus intestinalis*.

Since the larva generally burrows in the superficial layers of the skin, it may usually be removed by a very simple operation not requiring a local anesthetic and without injury to the blood vessels. Ordinarily it is difficult to locate the larva, which is not always found at the extreme end of the burrow. Austmann (*8*) used, with complete success, Lombard's method of clearing the epidermis by applying ordinary clear machine oil around the end of the burrow; he then was able to remove the larva with the point of a needle. A discussion of various types of treatment that have been used is given by Austmann.

**Literature.**—For important references to parasitism of man by *Gasterophilus*, see Austmann (*8*), Ségny (*138*), and Pavlovsky and Stein (*112*); for an extensive discussion of the biology and immature stages, see Dinulescu (*33*); for a taxonomic treatment, including keys to at least the three species of medical importance and extensive descriptions, see Wells and Knipling (*159*) (in English), Séguy (*135*) (in French), or Paramonov (*97*) (in Ukrainian).

## KEY TO SPECIES

### ADULTS

1. Wings clouded with a median band and 2 isolated spots near the apex (fig. 45); lower squama no larger than the upper 1; pile of abdomen short and inconspicuous, never bushy ..... *intestinalis* (Degeer)
   Wings unclouded; lower squama distinctly larger than the upper 1; abdomen in unrubbed specimens with considerable long bushy pile, at least at the base ..... 2
2. Vein $m_3$ distant by much more than its length from cross vein $r$–$m$ (fig. 42) ..... *haemorrhoidalis* (Linnaeus)
   Vein $m_3$ nearly meeting the cross vein $r$–$m$ (cf. *intestinalis*, fig. 45) ..... *nasalis* (Linnaeus)

### THIRD-STAGE LARVAE

1. Spines on the anterior margins of the segments arranged in a single row (fig. 44, *A*) ..... *nasalis* (Linnaeus)
   Spines on the anterior margins of the segments arranged in a double row, those of the front row being the more strongly developed ..... 2
2. Spines small, tapering to a fine point; spines lacking on at least the middle half of the dorsum of segment 10 and on the entire dorsum of segment 11 (fig. 44, *C*) ..... *haemorrhoidalis* (Linnaeus)
   Spines larger and stronger, blunt at the apices; only 1 or 2 pairs of spines lacking on the dorsum of segment 10; segment 11 with 1 to 5 spines above the lateral line on each side (fig. 44, *B*) ..... *intestinalis* (Degeer)

### FIRST-STAGE LARVAE

1. Spines at the anterior margins of the segments in one closely set row; body with some long scattered hairs; hooks on the ventral side of segment 2 very long (fig. 43, *A*) ..... *nasalis* (Linnaeus)
   Spines at the anterior margins of the segments in 2 rows; body with at most short, inconspicuous hair; hooks on the ventral side of the second segment not especially long, that is, no more prominent than the spines. 2
2. Larvae straplike, subfusiform (fig. 43, *B*) ..... *intestinalis* (Degeer)
   Larvae less elongated, fusiform (fig. 43, *C*) ..... *haemorrhoidalis* (Linnaeus)

## GASTEROPHILUS INTESTINALIS (Degeer)

The Common Horse Bot; the Nit Fly

(Fig. 45)

SYNONYM.—*Gasterophilus equi* (Clark).

RECOGNITION CHARACTERS.—Adult: This is a brownish-yellow fly; the thorax is somewhat darker than the head and abdomen; the latter may be marked with rather indefinite blackish spots and bands. The wings are marked with a grayish cross band at the middle and two spots at the apex. The hair of the abdomen is short and not very conspicuous. Length 12–17 mm. Larva: The newly emerged larva (fig. 43, *B*) is straplike and fusiform, tapering to both extremities; it is about 0.87 mm. in length, but may attain a length of 2 mm. or more before the completion of the stage. The color is translucent white. The posterior spiracles are borne at the end of prominent fleshy processes. The

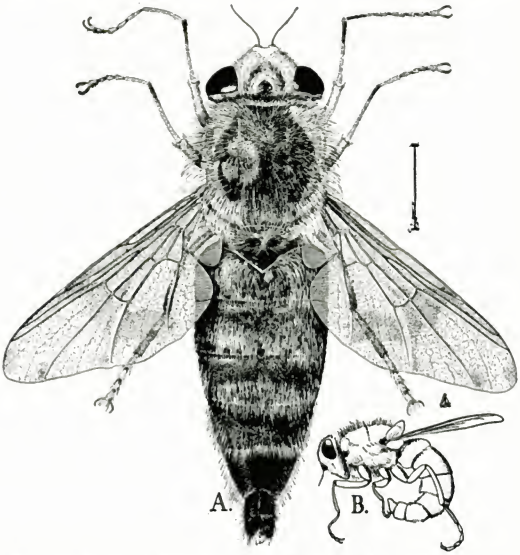


FIGURE 45.—*Gasterophilus intestinalis*, adult female: *A*, Dorsal view; *B*, sketch of side view.

second segment ventrally bears a number of spines, which are, however, no longer than some of the spines on the anterior margins of other segments. The third-stage larva (fig. 44, *B*) may be recognized by the characters given in the key.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Maryland, Virginia, North Carolina, Mississippi, Ohio, Michigan, Illinois, Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Montana, Idaho, Wyoming, Colorado, Utah, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Jamaica, Venezuela, Brazil, Chile, Argentina. Palaearctic Region: Scotland, England, Spain, France, Nether-

lands, Switzerland, Italy, Sicily, Sweden, Denmark, Germany, Austria, Rumania, Bulgaria, Russia (widespread), Canary Islands, Morocco, Algeria, Tunisia, Egypt, Turkey, Iraq, Iran, Siberia (Tomsk, Yenisseisk, Irkutsk, Transbaikal, Yakutsk, East Coast Province), Mongolia, China, Japan. Oriental Region: India (Madras). Ethiopian Region: Senegal, French Guinea, Gold Coast, Nigeria, Lake Tchad, Anglo-Egyptian Sudan, Eritrea, Belgian Congo, Kenya, Zanzibar, South Africa (Transvaal, Cape of Good Hope). Australian Region: New South Wales, Tasmania, New Zealand, Hawaii.

**Biology and Pathogenesis.**—On the normal host, the horse, the eggs are laid on hairs on various parts of the body, particularly on the inside of the knees. They are ready to hatch in about 7 days; however, hatching does not take place unless the eggs are rubbed by the warm lip of the horse as it bites itself in an attempt to soothe the itching presumably produced by the movements of the unhatched larva in the eggs attached to the hairs. In the absence of such a stimulus the larvae may remain alive in the eggs for as long as 3 months. The newly hatched larvae adhere to the horse's moist lips and soon penetrate the mucous coverings of the lips and tongue. Each female produces a large number of eggs, counts by various authors ranging from 397 to 1,046.

A number of cases of parasitism of man by this species in Europe, particularly in Russia, are on record; cases are also known from North America. According to Austmann, cases in man tend most frequently to occur on the extremities. Of the species of *Gasterophilus* known to attack man, this one apparently does so most frequently.

Anderson (*3*) records a case of a larva of *G. intestinalis* in the posterior chamber of the eye; however, it died there and did not cause any permanent damage.

### GASTEROPHILUS HAEMORRHOIDALIS (Linnaeus)

The Nose Bot; the Nose Fly; the Red-tailed Bot

Synonym.—*Haemorrhoestrus haemorrhoidalis* (Linnaeus) of Townsend's Manual.

Recognition Characters.—Adult: The head is yellow. The thorax and abdomen are mainly blackish in ground color; the pile is chiefly pale, except that the thorax and abdomen are each crossed by a band of black pile dorsally; the pile of the abdomen is reddish beyond the black cross band. The wing is unspotted; the venation is as in figure 42. Length about 12 mm. Larva: The larva may be distinguished by the key characters and figures 43, *C* and 44, *C*. The first-stage larvae are shorter and somewhat more robust than those of *G. intestinalis;* when first hatched they are also somewhat smaller (about 0.59 mm.).

Geographical Distribution.—Nearctic Region: Manitoba, Saskatchewan, Alberta, British Columbia, Virginia, Illinois, Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Montana, Idaho, Wyoming, Colorado, Utah, Washington, Oregon. Neotropical Region: Venezuela, Argentina. Palaearctic Region: Scotland, France, Netherlands, Italy, Corsica, Sicily, Malta, Sweden, Denmark, Germany, Austria, Rumania, Bulgaria, European Russia, Azerbaijan, Morocco, Turkey, Palestine, Iraq, Siberia (Tomsk, Yenisseisk, Yakutsk, Transbaikal), Mongolia, China. Oriental Region: India. Ethiopian Region: French West Africa, Belgian Congo, Kenya. Australian Region: Australia, Tasmania, New Zealand.

**Biology and Pathogenesis.**—In the normal host, the horse, the eggs are deposited on hairs on the lips and around the mouth. The number of eggs produced by each female is relatively small, 51 to 208, according to various counts but their survival ratio is relatively high.

The warmth and action of the saliva bring about a rapid hatching in 2 to 4 days; the young larvae then penetrate the skin of the lip and

work toward the mucous lining of the mouth, the subsequent migration to the stomach taking about a month.

Known cases of parasitism in man are not common, but several have been recorded within the range of this species in North America and Europe. According to Austmann, cases in man tend to occur most frequently on the face and buttocks.

### GASTEROPHILUS NASALIS (Linnaeus)

The Throat Bot; the Chin Fly

SYNONYMS.—*Gastcrophilus veterinus* (Clark); *Rhinogastrophilus nasalis* (Linnaeus) of Townsend's Manual.

RECOGNITION CHARACTERS.—Adult: The body is mainly blackish or brownish-black in background, the head, however, being reddish yellow; the pile is chiefly pale, that of the thorax being mainly reddish yellow, and that of the abdomen whitish or pale yellow, with a broad band of black pile crossing the intermediate segments. In the wing the two basal cells are of approximately equal length, the vein $m_2$ being nearly even with the cross vein *r-m*. Length 10–15 mm. Larva: Readily distinguishable from *G. haemorrhoidalis* and *G. intestinalis* by the characters given in the key and by figures 43, *A* and 43, *B*. The first-stage larva is much more slender, more nearly cylindrical, and more supple than the two species just mentioned.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Nova Scotia, Northwestern Territory, Quebec, Manitoba, Saskatchewan, Alberta, British Columbia, New York, New Jersey, Maryland, Ohio, Michigan, Illinois, Kentucky, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Montana, Wyoming, Colorado, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Jamaica, Puerto Rico, Antigua, Venezuela, Chile, Argentina, Panama. Palaearctic Region: France, Netherlands, Italy, Denmark, Germany, Austria, Rumania, Bulgaria, European Russia (widespread, southern part), Morocco, Egypt, Cyprus, Turkey, Iraq, Siberia (Tomsk), Turkestan, Semiretchje, Mongolia, China. Oriental Region: India. Ethiopian Region: French Guinea, Kenya, South Africa (Transvaal, Natal, Cape of Good Hope). Australian Region: Australia (Queensland), Tasmania, New Zealand, Fiji, Hawaiian Islands.

**Life History and Pathogenesis.**—On the normal host, the horse, the eggs are deposited on hairs beneath the jaws. Each female produces on an average about 450 to 500 eggs, the number in various counts ranging from 304 to 518. The larvae hatch in about 6 days and crawl into the horse's mouth, where they enter the mucosa of the cheeks or form pockets between the molar teeth, to complete the first instar.

This species has been accused of producing myiasis in man, but records of such may be the result of misidentification.

## The Family CUTEREBRIDAE

This family is here considered in the sense used in Townsend's "Manual of Myiology"; it is approximately equivalent to the Cuterebridae of Curran's "North American Diptera," except that that work omits the genus *Cephenemyia* and consequently the characterization of the family is not complete.

These flies are rather large; the more typical ones are bare or clothed with short hair, which may, however, form dense patches or even cover the thorax; one genus, *Cephenemyia*, resembles the bumblebee in appearance. The face is sunken, sometimes with a carina; the clypeus is narrow; the mouth parts are small or rudimentary, the flies being unable to take food in the adult stage. The chaetotaxy is usually undeveloped. The squamae are large; there is no postscutellum.

The larvae exhibit generic differences, but agree in several important respects. There is but one pair of mouth hooks, which are persistent through the last stage; the antennae are short and blunt, and bear two ocelluslike sclerotized structures at their apices; the anterior spiracles are present in the later stages; the posterior spiracles in the mature larva are prominent and oval or kidney-shaped, with or without a distinct button.

The larvae parasitize various mammals, only under abnormal circumstances living on nonmammalian hosts. They live either in the cavities of the head (*Cephenemyia*) or in furunculous subcutaneous tumors.

## KEY TO GENERA

ADULTS

1. Long-haired, bumblebeelike species; mouth parts very greatly reduced and not contained in an oral groove; ventral membrane of abdomen not exposed ..... *Cephenemyia* Latreille

   Short though sometimes densely haired species, not bumblebeelike in appearance; mouth parts somewhat more conspicuous and set in a distinct longitudinal oral groove; ventral membrane of abdomen exposed .. 2

2. Face only moderately excavated, with a distinct carina; tarsi broadened and flattened; large species, over 15 mm. and frequently over 20 mm. in length, often with more or less conspicuous dense pale hair on the thorax ..... *Cuterebra* Clark

   Face deeply excavated, without a carina; tarsi not broadened and flattened; species smaller than 15 mm. in length, and without conspicuous dense pale hair ..... *Dermatobia* Brauer

MATURE LARVAE

Elongated, cylindrical to club-shaped species, with patches of strong spines; last segment strongly developed, the posterior spiracles flush with its truncated apex, and a prominent conical extension below and beyond the spiracles (fig. 53) ..... *Cephenemyia* Latreille

Thick, ovoid species, thickly set with spines or scales; last segment short, the posterior spiracles set in a shallow spiracular cavity ..... *Cuterebra* Clark

Elongated, pear-shaped species, provided with rings of strong hooklike spines on the thicker median segments; posterior spiracles set in a deep spiracular cavity (fig. 50) ..... *Dermatobia* Brauer

### The Genus CUTEREBRA Clark

Rabbit Bots; Rabbit Warbles; Rodent Bots

This genus, strictly American in its distribution, contains a number of species which parasitize rodents and lagomorphs. Ban (*10*) and Townsend (*153*) have divided it into a number of genera, some of which, at least, have valid standing. Since the one record of parasitism of man [9] does not include a specific determination, there is no course possible here other than to treat the genus in its older, broad sense.

The key characters will suffice to separate *Cuterebra* from other myiasis-producing Cuterebridae. These flies are among the largest of the muscoids, usually 20 mm. or more in length and robust; the abdomen is usually, at least in large part, shining black or blue, though sometimes mainly pollinose, hairy, or reddish; the thorax is usually

[9] Since this manuscript was submitted for publication a case of human furuncular cutaneous myiasis caused by *Cuterebra buccata* was reported from Massachusetts by Bequaert (Psyche 52: 175–176, 1945).

duller than the abdomen and may be partly or wholly covered with opaque pollen or dense hair.

**Pathogenesis.**—The one case of parasitism of man by this genus is described by Beachley and Bishopp (*11*). A woman, while working in a yard in Arlington, Va., suddenly felt a sharp sting in her right nostril. Ten days later she felt violent pains in the right side of her face and extending into the throat, shoulders, and back; the following day a fully developed first-stage larva (fig. 46) of *Cuterebra* was sneezed out. Wild rabbits, chipmunks, squirrels, and field mice were known to have been in or near her yard at the time of infestation.

The species normally parasitize rabbits and other rodents; the larvae occur singly as subdermal parasites in cysts which open to the

FIGURE 46.—*Cuterebra sp.*, first-stage larva, from a case of human myiasis. (Beachley and Bishopp (*11*).)

outside. Occasionally dogs and cats are parasitized. Eggs are, at least in some cases, deposited at random in the ground near the entrance of the burrows of the host.

## The Genus DERMATOBIA Brauer

Only one species in this genus is now generally recognized; therefore, all discussion will be given under that heading.

### DERMATOBIA HOMINIS (Linnaeus Junior)

The Human Bot; the Neotropical Bot [10]

SYNONYMS.—*Oestrus hominis* Linnaeus Junior; *Dermatobia cyaneiventris* (Macquart); *Dermatobia noxialis* (Goudot).

RECOGNITION CHARACTERS.—Adult: This is a robust fly, about 12 mm. in length, that bears some superficial resemblance to the bluebottle fly. The head is mainly yellow, although its upper parts are darkened; the thorax is dull blue, somewhat clouded with pollen; the abdomen is metallic blue. The arista is pectinate; the face is rather deeply depressed, with only a vestigial carina; the proboscis, contained within a deep furrow on the ventral side of the head,

[10] Numerous local and vernacular names have been applied to this species. See page 104.

is short and cylindrical, with small but evident labella and without palpi. The wings and squamae are pale brownish, the legs mainly yellow. The propleura are clothed with distinct hairs; the pile of the abdomen, except at its base, is very short. The ventral membrane of the abdomen is distinctly exposed. Larva: The first-stage larva (fig. 48) is subcylindrical, somewhat narrower behind; the third and fourth segments are thickly set with small spines; the fifth to seventh segments have, in addition to the smaller spines, each a ring of heavy spines which usually occur in a single row ventrally and a double one dorsally; the eighth to twelfth segments are bare. After the first molt (fig. 49), the larva becomes pyriform, the bare posterior segments remaining narrow, but the more heavily spined anterior end becomes ovate to globular. The mature larva (fig. 50) is elongated-ovate, with the heavy spines somewhat reduced; the posterior spiracles are sunken in a cavity and consist each of three slits and

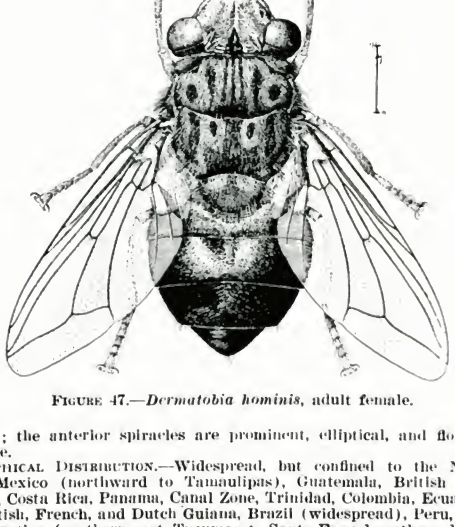

FIGURE 47.—*Dermatobia hominis*, adult female.

no button; the anterior spiracles are prominent, elliptical, and flowerlike in appearance.

GEOGRAPHICAL DISTRIBUTION.—Widespread, but confined to the Neotropical Region. Mexico (northward to Tamaulipas), Guatemala, British Honduras, Honduras, Costa Rica, Panama, Canal Zone, Trinidad, Colombia, Ecuador, Venezuela, British, French, and Dutch Guiana, Brazil (widespread), Peru, Paraguay, Chile, Argentina (northern part, Tucuman to Santa Fe and northward). Apparently absent from the Windward and Leeward Islands and the Antilles.

**Biology and Pathogenesis.**—This is primarily a forest species; it occurs chiefly in the wooded tracts and forest margins of the lowlands and river valleys, but it may range up to an altitude of 3,000 feet. This fly employs an interesting and unique method of insuring transportation of its eggs to the host. The adult female captures other Diptera and glues her eggs to their abdomens (fig. 51), the load apparently being gaged by the carrier's ability to transport them. The carriers chosen are day-flying mosquitoes (*Psorophora*), stableflies (*Stomoxys*), *Synthesiomyia*, and other Diptera that frequent the hosts of *Dermatobia;* rarely ticks are used in this way. When no carrier is

FIGURE 48.—*Dermatobia hominis*, first-stage larva. (After Newstead and Potts (9½).)

FIGURE 49.—*Dermatobia hominis*, second-stage larva.

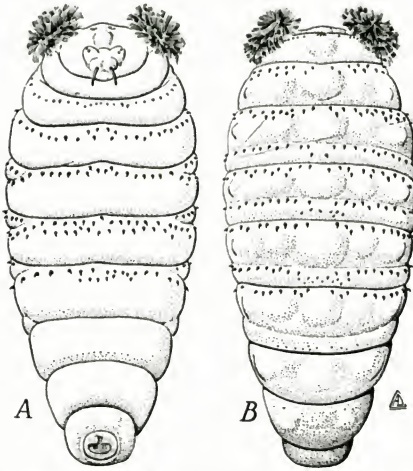


FIGURE 50.—*Dermatobia hominis*, mature larva: *A*, Ventral view; *B*, dorsal view.

available, the female may oviposit on foliage. The embryo hatches after 5 to 15 days, and abandons the empty chorion while the carrier is in contact with the host. If the carrier is a blood-sucking fly, it may further serve the parasite by providing a puncture in the skin to allow easier ingress. In the absence of such an opening the larva may penetrate the skin through a hair follicle, a fold, or some point where clothing, bedding, or the ground may come in contact with the moist, sweaty skin.

Each larva makes a separate lesion. It develops under the skin in a boillike pocket, opening to the outside, where it finally reaches maturity. The generally accepted number of larval instars is three, although Townsend claims that there are four. The duration of the larval life within the body of the host is usually from 5 to 10 weeks but sometimes runs over 3 months. The mature larva enlarges the opening and drops to the ground to pupate.

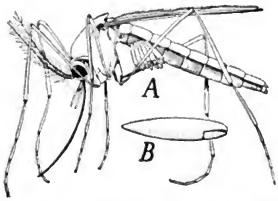


FIGURE 51.—*A*, A *Psorophora* mosquito carrying a load of *Dermatobia* eggs; *B*, egg, enlarged.

The larva produces a furunculous wound, which may be painful at intervals, usually of short duration. However, the discharges from the wound may be even more troublesome than the pain, when they foul bedding and clothing, and often acquire a fetid odor; furthermore, they invite infestation by other parasites, such as screwworms. A loss of energy and longer sleep requirements of the patient are noticed. Infection of wounds, especially those containing dead larvae, may have serious crippling effects. Cattle and dogs are often so heavily parasitized that death results.

The furunculous swellings frequently occur on exposed parts of the body, but they are also found on parts covered by clothing. The lesions occupy the area of the looser subcutaneous or areolar connective tissue. One fatal case resulting from the invasion of the brain of a child is on record (Dunn *36*).

The larva may be removed by pressure; but notice should be taken of the shape of the larva, with its narrower posterior end toward the opening. Since the larva depends on the outside atmosphere for its respiration, it may be forced to the surface by temporarily plugging the opening; if some such substance as soft beeswax or chewing gum is used, the larva may be trapped in it and in this way be more easily removed. Care should be taken to remove the larva intact, and, if possible, alive. A technique for removal, after anesthetizing the larva and the surrounding tissue of the host, is described by Harrell and Moseley (*55*).

In addition to man, *Dermatobia hominis* parasitizes cattle, dogs, and a number of other mammals, both wild and domestic; however, it apparently bothers Equidae relatively little. It has been reported from birds. It is a very serious cattle pest in many parts of tropical America.

**Vernacular Names.**—Some of the many vernacular names in use are as follows: Beef worm, macaw worm, mosquito worm, ver macaque,

gusano macaco, gusano de monte, colmoyote, cormollote, nuche, ver moyocuil, gusano de zancudo, hura, ura, torcel, and berne.

**Literature.**—The literature is voluminous. For general accounts see Townsend (*153, pt. 2, pp. 228–233; pt. 12, pp. 165–169*), Sambon (*130*); Newstead and Potts (*94*), and Vivas-Berthier (*155*); others are available. For a valuable historical sketch see Blanchard (*20*); for a case history in experimental self-infestation see Dunn (*35*); for the importance in human and animal parasitism see Dunn (*36*).

## The Genus CEPHENEMYIA Latreille

Flies of this genus live parasitically on the reindeer and deer, the maggots infesting various regions of the head and throat. The characters given in the key will serve to distinguish larvae (fig. 53) and adults from other Cuterebridae. The adults bear a superficial resemblance to some Hypodermatidae, but may readily be distinguished by the narrow epistoma, that of the Hypodermatidae being broad and shieldlike (fig. 52).

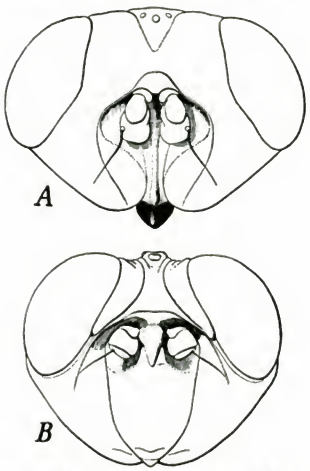


FIGURE 52.—Head of adult female, front view: *A, Cephenemyia trompe; B, Hypoderma bovis.*

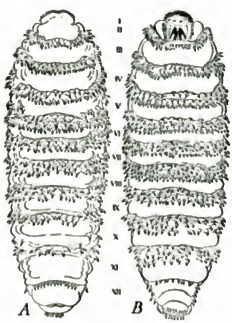


FIGURE 53.—*Cephenemyia auribarbis,* mature larva: *A,* Dorsal view; *B,* ventral view. (After Cameron (*23, p. 141*).

**Pathogenesis.**—It is probable that species of *Cephenemyia* never attack man. A case is recorded by Thompson (*149*) in which 40 larvae, identified in the then United States Division of Entomology as *Cephenemyia* sp., were removed from the nose of a man near San Bernardino, Calif., in 1889. In the light of present knowledge it seems likely that the larvae were misidentified and that they were actually *Oestrus.*

## The Family HYPODERMATIDAE

This family is here considered in the more restricted sense, as used in Townsend's "Manual of Myiology," and is approximately equivalent to the Hypodermatinae of Pleske (*113*) and Séguy (*135*). Many authors have considered it a part of the Oestridae or Larvaevoridae (Tachinidae).

With the exception of some of the rarer species which are not known to be of medical importance, the flies are rather robust and beelike in appearance and more or less densely clothed with bushy hair. The front is wide, especially in the females; the third antennal segment is short and rather strongly receding into the second; the epistoma is widened and shieldlike; the head and thorax, in all species of known medical importance, lack well-developed bristles; the hypopleura, however, possess tufts of strong hairs; the lower squamae are strongly developed and much larger than the upper ones; cell $r_5$ is strongly narrowed at the apex, and the anal vein is short, though sometimes prolonged by a fold; the middle and hind femora, at least, are thickened at the base.

The adult flies take no food and are rarely seen except in the vicinity of their hosts. The normal hosts of the different species include various mammals, particularly cattle, deer, reindeer, antelopes, and rodents. Man occasionally is an abnormal host of three species that have been recorded, all in the genus *Hypoderma*.

### The Genus HYPODERMA Latreille

Synonyms.—*Atelecephala* Townsend; *Litholypoderma* Townsend.

This genus may readily be distinguished from the other members of this family known to science by the following combination of characters: The clypeus is hollowed out to receive the antennae, but the two antennal foveae are separated by a narrow carina, the width of which is less than the diameter of the third antennal segment; this carina, however, does not extend below the antennal pockets (fig. 52). The clypeus is pilose; palpi are completely absent. The bristles of the head, thorax, and abdomen are undeveloped. The tibiae are dilated in a dorsoventral axis in the middle. The scutellum is bare and polished at the apex, and more or less distinctly notched in the middle.

**Life Histories.**—Eggs are attached to hairs on the lower part of the body, usually the legs, of the host. They hatch without friction or moisture, and the young larvae immediately burrow into the skin at the base of the hair. The supposition that eggs are taken into the digestive tract and hatched there has been disproved. The first-stage larva makes its way by a more or less circuitous route through the intermuscular connective tissues, finally lodging in the back of the animal. In the course of its wanderings it may penetrate the spinal canal. The larva then forms a pocket, or warble, in the connective tissue of the back, cuts a hole through the skin to the surface, and molts, in the process of which it loses its functional mouth hooks. The third larval stage is also passed within the warble, the mature larva then making its way out and dropping to the ground to pupate. The completion of the life cycle takes a year, most of which is spent in the body of the host.

The number of larval stages has been the subject of much disagreement, but evidence very strongly indicates the presence of only three stages (Knipling (*72*), Patton (*107*)). Others believe that there are four or five, or, in other words, that the larva molts once or twice in the course of its travels from the point of entrance to its final resting place on the back.

**Larva.**—The young larva is a soft-bodied, robust, fusiform grub, somewhat broader behind than in front, and rather densely covered with small spines, which seem to thin out, however, as the stage develops. The spines are more densely set toward the anterior margins of the segments. The mature grub (figs. 56 and 57) is a tough-skinned creature that can hardly be crushed by pressure when squeezed between the thumb and index finger; it is rounded at both ends, and bears rows and isolated islets of spines which can easily be felt by the fingers as roughened areas. The mouth hooks, which are well developed in the first stage, become rudimentary after the first molt.

**Etiology and Pathogenesis.**—Numerous records are on hand of attacks on man by *Hypoderma bovis*, *H. lineatum*, and *H. diana*. Most case histories reveal some association with cattle during the summer or fall preceding the attack. Parasitism is accompanied by severe discomfort, and the results may be serious or even fatal. Adults are often attacked, but the number of cases of hypodermyiasis among children is proportionately very high.

As in cattle, ingress is probably through the skin. The first symptoms usually occur during the winter months. Abdominal pains or stomach disorders may be experienced; and as the larva wanders through the subcutaneous connective tissues, severe discomforts, itching, pains, and cramps may be felt. The wanderings of the larva may be extensive and rapid; they are usually in an upward direction, although the larva may temporarily pass down an arm or leg and then retrace its course. The path of the larva may be traced by the localized painful or swollen areas, or by indefinite reddish lines; but since, unlike *Gasterophilus*, its burrows are through the loose, subcutaneous connective tissues, it does not leave nearly so definite a trail.

When the larva is ready to molt, it produces indurated swellings, usually on the upper part of the chest or back, or on the head or neck. Since conditions in the human body are abnormal for the larva, it may move toward the surface several times in an attempt to find just the right situation for the formation of the warble. The swelling then becomes domelike and an opening develops through which the larva may be expelled. If the larva is forced out of the warble, a quantity of serous or pustular fluid is also expelled. This fluid has been produced by the action of the spines of the larva and of the microorganisms that enter from the air; it is upon this fluid that the larva feeds during its later stages.

The pain and discomfort accompanying parasitism may be severe and the patient may be temporarily unable to use an invaded limb. An apparently accelerated night activity of the larva may make sleep difficult or impossible. Sometimes the results are more severe. In the case of a boy in Montana, who was parasitized by seven larvae of *H. lineatum*, almost complete paralysis of the lower extremities resulted, and a year later it had not completely cleared up; this may

have been due to penetration of the spinal cord. In another case a small boy died after a larva had produced a fetid ulcer around the back teeth of the lower jaw.

Occasionally first-stage larvae enter the eye, sometimes through the optic nerve. Cases have been recorded in which larvae were found in the eyeball, sometimes in the posterior and sometimes in the anterior chamber. The larva may usually be removed from the anterior chamber, but in the posterior it is more difficult to reach; it may work beneath the retina and detach that structure. Such parasitism may result in the loss of an eye. Intense pain may be felt, sometimes accompanied by nausea and vomiting.

Because of the confusion regarding the number of larval stages, it is not always possible to tell from published accounts how far the parasite had progressed in its development. In one case, however, eight out of nine larvae of *H. diana* removed from a human subject pupated, and two of these developed into adult males.

Treatment consists in removal of the parasites. If an open warble has been formed, the grubs can be squeezed out by pressure; if not, removal by surgical means may be indicated. To remove the larva from the anterior chamber of the eye, an operation is necessary; larval parasitism of the posterior chamber may necessitate the removal of the eyeball.

**Literature.**—For a general account of the life history, biology, and veterinary and medical aspects, including some case histories, see Bishopp, Laake, Brundrett, and Wells (*18*); for taxonomy, in addition to the above, see Patton (*107*) and Toomey (*152*); for medical and clinical aspects, see Toomey (*153*); for discussions of ophthalmomyiasis, see Anderson (*3*) and O'Brien and Allen (*95*).

## KEY TO SPECIES

### ADULTS

1. Abdomen with reddish-yellow pile at the apex; scutellum with but shallow emarginations at the sides or apex ..... 2
   Abdomen with yellowish pile at the apex; scutellum with deep emarginations at the apex and the sides, thus appearing as 4-lobed ... *diana* Brauer
2. Scutellum only very indistinctly notched at the apex; first segment of each tarsus slightly longer than the following 3 combined; mesonotum conspicuously reddish-yellow pilose in front, black behind ... *bovis* (Linnaeus)
   Scutellum slightly, but distinctly, notched at the apex; first segment of each tarsus equal to or shorter than the combined length of the following 3; mesonotum uniformly yellow-pilose ..... *lineatum* (Villers)

### LARVAL STAGES [11]

Mouth hooks present; posterior spiracles consisting of simple circular openings ..... stage I
Mouth hooks rudimentary; posterior spiracles with 18 to 40 openings, arranged in squarish or irregular masses and not surrounding a button ..... stage II
Mouth hooks rudimentary; posterior spiracles with numerous openings, kidney-shaped, and partially surrounding the button (fig. 55) ..... stage III

[11] The characters for differentiating the larvae have been taken from various sources, but chiefly from Laake. However, Natvig (*92*) has shown that they do not always hold; so they should be used with caution. If exact and positive determination is necessary, it will be best to consult the Laake and Natvig papers.

STAGE I (Stages I to III of Lanke)

1. Mouth hooks with the anterior end directed forward and blunt, and with the posterior end divided by a shallow incision into 2 blunt lobes (fig. 54, *A*)---------- *diana* Brauer

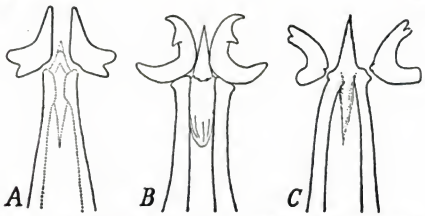


FIGURE 54.—Mouth hooks and anterior part of cephalopharyngeal skeleton of first-stage larva: *A, Hypoderma diana; B, H. lineatum; C, H. bovis.* (A redrawn from Schmid (*152, p. 231*); *B* and *C* after Bishopp and coworkers (*18*).

Mouth hooks with the anterior end directed outward and the posterior end not divided into 2 lobes---------- 2

2. Mouth hooks with the anterior end sharp and undivided; a pointed, recurved tooth some distance behind the anterior end (fig. 54, *B*) *lineatum* (Villers)

Mouth hooks with the anterior end divided into 2 blunt lobes; no recurved pointed tooth (fig. 54, *C*)---------- *bovis* (Linnaeus)

STAGE II (Stage IV of Lanke)

Stigmal plates of posterior spiracles orange or yellowish brown; the discs separate or loosely connected, 12 to over 20, but usually 18 to 25, in number---------- *lineatum* (Villers)

Stigmal plates of posterior spiracles brown to black; the discs closely grouped together and fused, 29 to over 40, usually 32 to 37, in number. *bovis* (Linnaeus)

STAGE III (Stage V of Lanke)

1. Tenth segment devoid of spines above and below; the posterior stigmatal plate deeply excavated funnel-like toward the button (fig. 55, *A*)---------- *bovis* (Linnaeus)

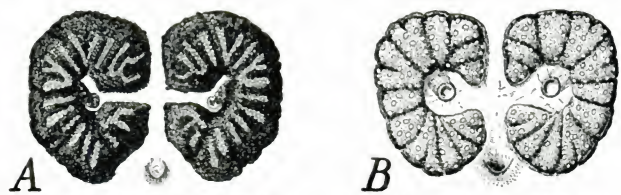


Figure 55.—Posterior spiracles of mature larva: *A, Hypoderma bovis; B, H. lineatum.*

Tenth segment with spines ventrally; the posterior stigmatal plate more shallowly excavated toward the button (fig. 55, *B*)---------- 2

2. Segment 10 ventrally with an anterior row but without a posterior band of spines; segments 8 and 9 dorsally without posterior bands of spines; the posterior spiracles divergent (figs. 56, *A* 57, *A*)-------- *diana* Brauer

Segment 10 ventrally without an anterior row of spines; posterior bands of spines present on segment 10 ventrally and on segments 8 and 9 dorsally; posterior spiracles not divergent (figs. 56, *B* 57, *B*).
*lineatum* (Villers)

### HYPODERMA DIANA Brauer

The Deer Warble Fly

SYNONYM.—*Alelecephala diana* (Brauer) of Townsend.

RECOGNITION CHARACTERS.—Adult: This is a beelike species, but does not have the strong resemblance to a bumblebee that *H. bovis* does; it is also much less

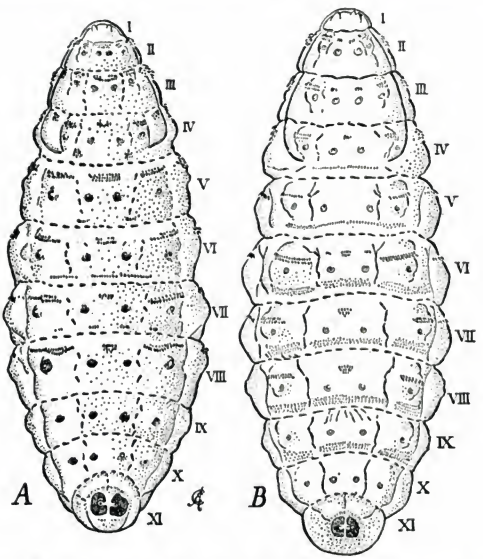


FIGURE 56.—Mature larva, dorsal view: *A*, *Hypoderma diana*; *B*, *H. lineatum*. (After Cameron (*23, p. 136*).)

robust. The body is grayish-yellow haired, with some darker hair on the middle part of the abdomen dorsally, more in the female than in the male. The mesonotum bears four polished longitudinal stripes which are interrupted at the suture. The legs are yellowish brown, the femora more or less extensively blackish. Length 10–12 mm. Larva (figs. 56, *A* and 57, *A*): Sufficiently characterized in the key.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Central and southern Europe: Scotland, France, Germany, Austria, Bulgaria.

**Life History and Pathogenesis.**—The normal hosts are the red deer (*Cervus elaphus*) and the roe deer (*Cervus capreolus*) of Europe. Its biology, as far as known, is similar to that of *Hypoderma bovis*.

**Literature.**—Cameron (*22 and 23*); Patton (*107*).

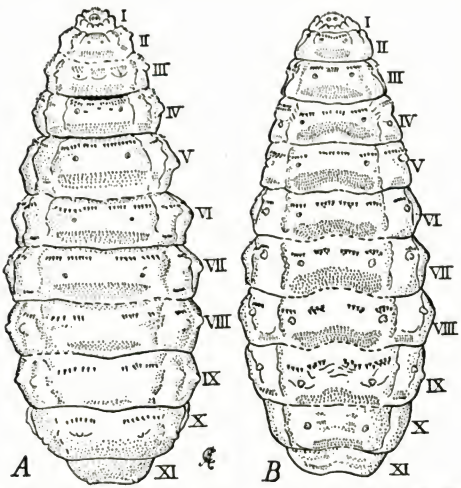


FIGURE 57.—Mature larva, ventral view: *A, Hypoderma diana; B, H. lineatum.* (After Cameron (*23, p. 137*).)

## HYPODERMA BOVIS (Linnaeus)

The Northern Cattle Grub

RECOGNITION CHARACTERS.—Adult: This is a dark, rather robust bumblebee-like fly, about 12 mm. in length. The head and thorax are clothed mainly with golden-yellow hairs except on the mesonotum behind the suture, where the vestiture is black, the black background showing through to form a prominent cross band. The mesonotum bears four polished longitudinal stripes, broadly interrupted at the suture. The abdomen is clothed with long yellow hair which becomes reddish toward the apex. The femora are mainly black, the tibiae brown, and the tarsi yellowish brown. Larva: The stages are sufficiently characterized in the keys.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Canada (all parts; specific records from Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia); Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, Virginia, Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, North Dakota, South Dakota, Nebraska, Montana, Wyoming, Oregon (also from cattle imported into Florida, Texas, and Alabama). Neotropical Region: Puerto Rico (from imported cattle), Jamaica (on imported cattle), Brazil (questionable record), Chile (on imported cattle; unable to develop). Palaearctic Region: Ireland, Scotland, Wales, England, Spain, France, Netherlands, Switzerland, Italy, Sicily, Norway, Sweden, Finland, Denmark, Germany, Poland, Austria, Rumania, European Russia, Morocco, Algeria, Libia, Egypt, Cyprus, Kazak, Siberia (Tomsk), Inner Mongolia, China, Manchuria. Ethiopian Region: South Africa (on imported cattle; unable to develop). Australian Region: New Zealand (recorded, but not established).

**Life History and Pathogenesis.**—The normal hosts are cattle. Eggs are laid singly; the greater activity necessary for such deposition produces a high pitch of excitement among the cattle. The eggs hatch

in about 3 to 7 days; the route of the larva through the host is not definitely known, but it apparently does not have a lodging stage in the esophagus, as does *H. lineatum*.

In man parasitism by this species is not significantly different in its clinical aspects from that of other members of the genus. Numerous cases are on record from northern North America and northern Europe.

**Literature.**—Bishopp and coworkers (*18*); Patton (*107*).

## HYPODERMA LINEATUM (Villers)

The Common Cattle Grub; the Heel Fly

(Fig. 58)

SYNONYM.—*Lithohypoderma lineatum* (Villers) of Townsend.

RECOGNITION CHARACTERS.—Adult: This species is also beelike in appearance but is less robust and hairy than *H. bovis* and does not have so strongly the

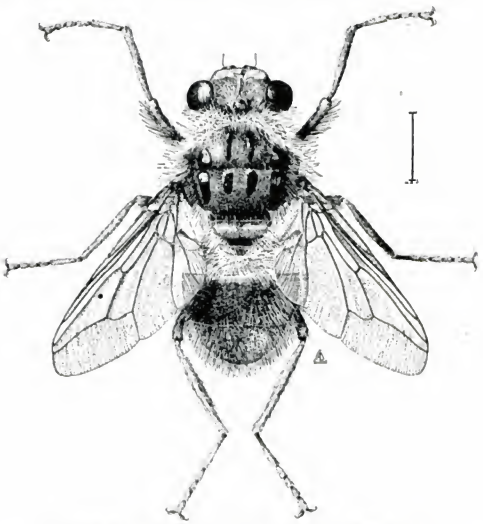

FIGURE 58.—*Hypoderma lineatum*, adult female.

aspect of a bumblebee. The mesonotum is covered lightly with pale hairs which may not be noticeable to the naked eye except from a front view; the thorax bears four polished stripes which are briefly interrupted at the suture; these stripes stand out more prominently than they do in *H. bovis*. The abdominal pile is grayish yellow at the base, brownish to black in the middle, and bright orange at the apex. The femora are dark brown to black, the tibiae and tarsi light brown. Length about 12 mm. Larva (figs. 56, *B* and 57, *B*): Sufficiently characterized in the key.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Canada (Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia), United States (recorded from every State and the District of Columbia). Neotropical Region: Santo Domingo, Puerto Rico (introduced many times, but not established). Palaearctic

Region: Ireland, Scotland, Wales, England, Portugal, France, Netherlands, Switzerland, Italy, Sicily, Norway, Denmark, Germany, Austria, Poland, Rumania, Bulgaria, European Turkey, Caucasus, European Russia (widespread, central and southern), Morocco, Algeria, Tunisia, Cyprus, Syria, Iraq, Iran, Inner Mongolia, China, Manchuria. Oriental Region: India (Punjab, Northwest Frontier Provinces, Sind), Baluchistan. Ethopian Region: South Africa (on imported cattle). Australian Region: Hawaiian Islands.

**Life History and Pathogenesis.**—The normal hosts are cattle. Eggs are deposited in rows of 5 to 20 or more on a hair; they hatch in 3 to 7 days, and the larva eventually makes its way to the submucosa of the esophagus, where it remains for a while before resuming its journey to the back.

In man parasitism by this species is not significantly different in its clinical aspect from that of other members of the genus. Numerous cases are recorded from temperate North America and Europe.

**Literature.**—Bishopp and coworkers (*18*); Patton (*107*).

## The Family OESTRIDAE

The family is considered here in a restricted sense, equal approximately to the Oestrinae of Pleske (*113*) and of Rodhain and Bequaert (*123*), and to the Oestrini of Townsend's "Manual of Myiology." Most authors use the family name in a much broader sense, to include the Hypodermatidae, Cuterebridae, and Gasterophilidae, or at least the first or the first and second of these. On the other hand, Townsend separates those families from the Oestridae, but includes, perhaps correctly, a number of species of no medical importance which are usually considered larvaevorid.

As restricted here, the family may be characterized as follows: The head is large, the front being broadly separated in both sexes and the lower parts being rather swollen. Ocelli are present and, in the species treated here, large; the proboscis is greatly reduced, but the palpi are distinctly present. The antennae are short, the third segment being more or less swollen; the arista is thickened basally, thin for the remainder of its length, and bare. The transverse suture of the mesonotum is complete; a distinct postscutellum is present; thoracic bristles are completely undeveloped, the metapleura, sternopleura, and hypopleura being clothed only with long hairs. The squamae are large; the apical cell is closed and petiolate. The abdomen is rather short and conical, the ventral membrane being distinctly visible.

The larva is rather robust and not much tapered anteriorly. The third-stage larva has a single pair of mouth hooks; the anterior spiracles are inconspicuous or absent; the posterior spiracles are in the form of two sclerotized plates perforated by numerous pores; the button is present and more or less surrounded by the spiracles; below the spiracles is a swelling of ambulatory function.

The larvae live parasitically in the nasal region and frontal or maxillary sinuses of sheep, goats, horses, antelopes, and other hoofed mammals. Abnormally, the species attack man, the larva usually entering the eye capsule or the eye itself, but sometimes the nose or mouth. In man larvae are unable to develop beyond the first stage, probably because they cannot find the proper conditions under which to transform.

An excellent account of the African species is given by Rodhain and Bequaert (*123*); the European species have been treated by Pleske (*113*) and Séguy (*135*).

## KEY TO GENERA

ADULTS

Proboscis very short, not extending between the palpi; abdominal sternites broad and quadrate, clothed with long, fine hairs ..... *Oestrus* Linnaeus

Proboscis very short, but conical and extending backward between the palpi; abdominal sternites narrow and tending to be triangular, only short-haired ..... *Rhinoestrus* Brauer

THIRD-STAGE LARVAE

Posterior spiracles D-shaped, completely surrounding the button; dorsal spinous areas of the segments lacking, or at most greatly reduced ..... *Oestrus* Linnaeus

Posterior spiracles crescent-shaped, not completely surrounding the button but sometimes almost so; 2 or more rows of spines on each of segments 3 and 4, these being absent only in one species not within the scope of this work ..... *Rhinoestrus* Brauer

FIRST-STAGE LARVAE

Anal spines arranged in two groups of 9 to 11 each; oral hooks horulike (fig. 59) ..... *Oestrus ovis* Linnaeus

Anal spines 8 to 10, medially located; oral hooks clawlike (fig. 60) ..... *Rhinoestrus purpureus* (Brauer)

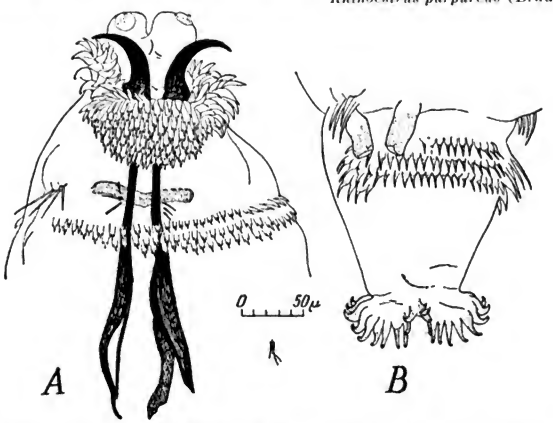


FIGURE 59.—*Oestrus ovis*, first-stage larva: *A*, Anterior end; *B*, posterior end. (After Galliard (*42, p. 179*).)

### The Genus OESTRUS Linnaeus

In this genus the front is broadly and strongly convex; the parafrontals are prominent, with numerous pocklike pits, from each of which a hair arises. The antennae are short and separated by a

distance somewhat less than the diameter of the spherical third segment. The clypeus is depressed above, forming two pits below the antennae which are strongly confluent. The proboscis and palpi are reduced to three buttonlike structures; the proboscis is directed backward, but does not extend between the palpi (fig. 61). The legs are short. For the characteristic wing venation, see figure 62; vein *r-m* joins the discal cell at more than half its length; vein $m_3$ arises much nearer to the cubitulus than to the cross vein *r-m*; the petiole of the apical cell curves more or less strongly upward. The abdomen is moderately robust and not especially flattened; the sternites are broad and rectangular, and the venter is distinctly haired below.

**Life Histories.**—The larvae are normally parasitic on sheep, goats, and antelopes; occasionally those of one species, *Oestrus ovis*, attack man. First-stage larvae are produced alive. They are deposited

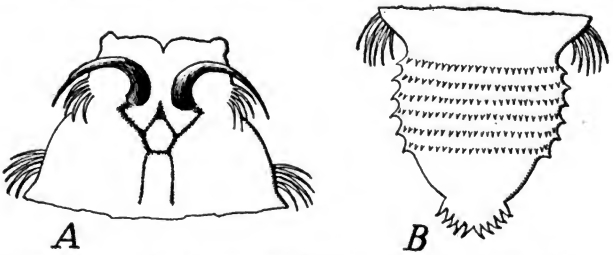


FIGURE 60.—*Rhinoestrus purpureus*, first-stage larva: *A*, Anterior end; *B*, posterior end. (Redrawn from Portchinsky (*117*).)

around the nose of the host. Subsequently, they enter the nasal passages and finally make their way into the frontal sinuses. At maturity they leave the body of the host and drop to the ground to pupate.

**Larva.**—The third-stage larva can be distinguished from those of other genera by the following combination of characters: The antennae are short and thick, and each bears two ocelli. The ventral surfaces of the segments are extensively provided with small spinules; these are absent on the dorsum, except in one species not included in this work. The posterior spiracles are D-shaped and completely enclose the button; a transverse suture extends from the button to the inner margin of the spiracle. The postanal swelling bears a pair of conical lateral protuberances.

### OESTRUS OVIS Linnaeus

The Sheep Bot; "Grub-in-the-Head"

(Fig. 62)

SYNONYM.—*Cephalomyia* (*or Cephalomyia*) *ovis* (Linnaeus).

RECOGNITION CHARACTERS.—Adult (fig. 61): The head is yellowish, the depressed pocklike pits of the parafrontals and the third antennal segments being black; the frontalia are on a level with the parafrontals. The pits of each parafrontal are rather deep and numerous, the number of those bordering the frontalia being about 12. The thorax is covered with a grayish bloom, the black background exposed in the form of 4 stripes; the bloom is interrupted by numerous

small tubercles, each bearing a hair. The legs are yellow. The wings are but little longer than the thorax and comparatively broad, the apical cell being about three times as long as broad. The abdomen is black, with a pattern of irregular grayish spots, which appear to change with the light incidence. Length 10–12 mm.

Larva: The larva is distinguishable only with difficulty from other members of the genus, but is readily distinguishable from *Rhinoestrus purpureus*, the only other oestrid known to be of medical importance.

In the whitish, robust, third-stage larva spinulose areas are absent from the head and from the dorsal surface of the body; on the anterior margin of the ventral surface the third segment bears one to two rows, the fourth and fifth each two to three rows, the sixth and seventh each three to four rows, the eight, ninth, tenth, and eleventh each four to five rows, and the twelfth (anal) segment two rows.

FIGURE 61.—*Oestrus ovis*, head of female, ventral view, showing rudimentary proboscis and palpi.

The first-stage larva is a small, white elongate-oval creature, about 1 mm. in length. The strong buccal hooks (fig. 59, *A*) are recurved and hornlike, the strong bend beginning slightly before the middle; the last segment (fig. 59, *B*) bears 2 prominences, each of which possesses 10 or 11 (sometimes 9) hooklets; the shape of each hooklet has been compared by Portchinsky to the tooth of a shark. The spinulation of the segments is weak and hard to see, except from prepared slides; the arrangement of the spines, according to Larrousse (*80*), is as follows: Dorsally, the third segment has 3 rows of spines anteriorly; each of the others has 2 complete rows, with a partial row in the middle consisting of 8 to 12 spines; the number of rows increases laterally. Ventrally, each segment has 3 rows of spines, the last segment sometimes with an incomplete fourth. The posterior spiracles are reduced to small rounded openings, barely visible and not encircled by sclerotized plates.

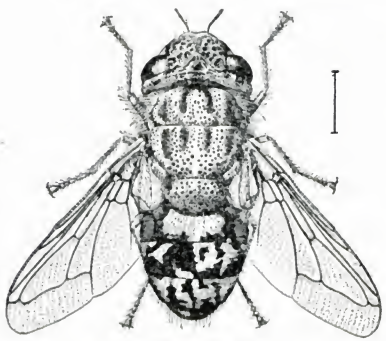

FIGURE 62.—*Oestrus ovis*, adult female.

GEOGRAPHICAL DISTRIBUTION.—Practically worldwide, wherever native or domestic sheep and goats are found. Nearctic Region: Ontario, Alberta, Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Virginia, Georgia, Florida, Mississippi, Ohio, Michigan, Kentucky, Minnesota, Iowa, North Dakota, Texas, Montana, Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico, Puerto Rico, Brazil (Rio de Janeiro and southward), Peru, Uruguay, Chile, Argentina. Palaearctic Region: Ireland, Scotland, England, Spain, France, Netherlands, Switzerland, Italy, Corsica, Sardinia, Sicily, Denmark, Germany, Czechoslovakia, Austria, Yugoslavia, Bulgaria, Greece, European Turkey, European Russia, Cape Verde Islands, Canary Islands, Morocco, Algeria, Tunisia, Libia, Egypt, Cyprus, Syria, Palestine, Iraq, Iran, Kazak, Turkestan, Tadzhik, "Transcaspia," Semiretschje, Mongolia, China. Oriental Region: India (widespread), Taiwan. Ethiopian Region: Senegal, Nigeria, Anglo-Egyptian Sudan, Belgian Congo, Kenya, Tanganyika, Zanzibar, Mozambique, South-West Africa, South Africa (Basutoland), Mauritius, Rodriguez. Australian Region: South Australia, Queensland, Tasmania, New Zealand, Hawaiian Islands.

**Life History and Pathogenesis.**—The adults take no food. While in flight, the fly will deposit larvae near the nostrils of sheep or other animals suitable as hosts; the larvae then pass through the nasal cavity into the ethmoidal, the frontal, or the maxillary sinus, where they transform into the second instar. There the larval stage is completed, and the mature larvae drop to the ground to pupate. The duration of the immature stages varies considerably, but is more rapid in warmer climates or seasons; the larval stage may be completed in from 2½ to 12 months, or even in 25 days, and the pupal stage in 3 to 4 weeks. In Europe there is supposedly one annual generation, although evidence points to two in North America.

Though not a normal host, man is often infested, especially when he is closely associated with sheep or goats. Apparently he may be infested at any time during the summer or early fall. Numerous cases of myiasis in man are on record, and it is probable that the infestation is even more common than the literature would indicate. Several cases are from the United States; in some parts of Russia, Italy, North Africa, and on the Cape Verde Islands it is a common affliction.

In human beings this parasite usually affects the conjunctiva of the eye, to produce a painful, but usually not serious, form of conjunctivitis. The larva can never progress beyond the first stage. In the typical case history the patient will report being struck in the eye by an insect or small foreign object, with pain and inflammation developing a few hours later. The larva, because of its small size and transparency, is hard to see, and the cause of the conjunctivitis may easily be missed. As many as 50 larvae have been removed from the conjunctival sac of a single patient, although usually the number is much less. Cases of ocular myiasis caused by this parasite resemble cases of acute catarrhal conjunctivitis, and may be diagnosed as such. Since the parasite cannot develop, the trouble usually lasts but a few days.

In Algeria native shepherds are subject to the attacks of the sheep bot, which sprays its larvae into the eyes, nose, and throat. Attacks occur chiefly where the sheep population is sparse as compared with the human population. The flies may be attracted by the odor of cheese which the natives eat. Similar cases have been reported from Italy and from the Cape Verde Islands. In oral and nasal myiasis, known as thim'ni in Algeria and as tamné in the Ahaggar Mountains of the central Sahara, the parasite penetrates the nasal cavities and frontal sinuses, where it may cause swelling and severe pain, with frontal headaches that make sleep impossible, or enters the mouth causing inflammation of the throat which makes swallowing difficult. The symptoms may last from 3 to 10 days, or longer in the case of inflammation of the nose.

This species has also been reported to be involved in myiasis of the ear, the larva attacking the membrane of the outer auditory meatus and causing considerable pain, although not penetrating the tympanum.

**Literature.**—Portchinsky's (*116*) monograph gives the most complete account of this parasite in relation to man. For a discussion of the first larval stage in comparison with that of *Rhinoestrus purpureus*, see Larrousse (*80*), and for the other larval, pupal, and adult stages and the biology, see Rodhain and Bequaert (*123*). For some complete case histories, symptomology, and diagnosis, see Dupuy d'Uby (*37*).

## The Genus RHINOESTRUS Brauer

As in *Oestrus*, the front is broad and strongly convex, with prominent parafrontals which bear, however, instead of pits, numerous tubercles, each provided with a hair; similar although less prominent tubercles may occur on the parafacials. The antennae are short and separated at the base by a distance somewhat less than the diameter of the spherical third segment. The clypeus is depressed above, forming two pits which are strongly confluent. The palpi are reduced to the form of two buttons; the proboscis is greatly reduced, but its cone-shaped rudiment extends backward between the palpi to a level with the posterior margin (fig. 63). The legs are short. The wing venation is similar to that of *Oestrus*; vein $r_1$ is at least halfway along the discal cell; vein $m_3$ arises much nearer to the cubitulus than to the cross vein *r-m;* the petiole of the apical cell curves more or less strongly forward. The abdomen is moderately robust and not strongly flattened; the sternites are narrow, as a rule much under the width of the exposed membrane on each side, and tend toward a triangular shape; the hairs of the venter are short and inconspicuous.

**Life Histories.**—The larvae are normally parasitic in the head sinuses of various ungulates, including horses, hippopotami, forest duikers, and native African Suidae. One species, *Rhinoestrus purpureus*, has been reported to have attacked man in the same manner as does *Oestrus ovis;* however, some records of *Rhinoestrus purpureus* parasitizing man have been due to misidentifications of *Oestrus ovis*. As in *Oestrus*, first-stage larvae are produced alive and subsequently attack the host through the nasal openings; pupation takes place in the ground.

**Larvae.**—The third-stage larvae can be distinguished from those of other genera by the following combination of characters: The antennae are well-separated; each bears a pair of ocelli. Segments 3 to 11, are provided with anterior areas of small spines ventrally, each consisting of at least one, usually two or more, complete rows; dorsally, segments 3 to 8 (except in one African species not treated here), are provided with similar spinous areas which may be confined to the lateral margins of the segments, but which form at least two complete rows on segments 3 and 4. The posterior spiracles are crescent-shaped and extend around but do not completely encircle the button. The postanal swelling is provided with two conical lateral protuberances.

The first-stage larvae of *Rhinoestrus purpureus* may easily be distinguished from those of *Oestrus ovis* by the characters given in the key.

### RHINOESTRUS PURPUREUS (Brauer)

The Russian Bot (Russkii Ovod); Russian Gadfly; l'Oestre du Cheval

(Fig. 63)

Synonyms.—*Oestrus purpureus* (Brauer); *Cephalomyia purpurea* (Brauer); *Rhinoestrus nasalis* of Brumpt, Fülleborn, etc., not *Oestrus nasalis* Linnaeus.

Recognition Characters.—Adult: The body in general is chocolate brown, the thorax somewhat darker than the head and abdomen and, in life, with a number of purplish spots which often disappear in the dried insect. The abdomen is marked with irregular shining silvery spots which change shape with the light incidence. The antennae are brownish, the third segment being almost or quite black. The integument of the head, thorax, and abdomen is adorned with

a number of coarse tubercles, each bearing a hair; they are most pronounced on the dorsal surface of the scutellum and abdomen, where many of them are mammillate in shape; there are none, however, on the genae. Length about 8–11 mm. Larva: The third-stage larva is elliptical, broadest in the middle and narrowing toward each end, which is rounded. The spinulation is characteristic. The spinules are present in 3 to 4 rows on segments 3 to 5 ventrally and in 4 rows on segments 6 to 11 ventrally; segment 12 is densely covered with spinules ventrally. On the dorsal surface 3 rows of spinules are present on segments 3 to 6; segments 7 and 8 have small patches of them laterally. The first-stage larva is about 1 mm. in length, whitish, broadest in the middle, and tapering toward each end. The strong buccal hooks are bent near their base; their shape is clawlike rather than hornlike (fig. 60, *A*). Dorsally each segment has 2 rows of spinules, additional rows being added toward the sides; ventrally, the second segment has 2 rows, the third and fourth each 3, the next 6 each 4, and the last segment 6 rows, of spines; the spinulation is weak and transparent, and a compound microscope is required to show them to advantage. The last segment possesses a single series of 8 to 10 median hooks (fig. 60, *B*).

FIGURE 63. — *Rhinoestrus purpureus*, head of female, ventral view, showing rudimentary proboscis and palpi.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Spain (Andalusia), France, Italy, Austria, Rumania, Bulgaria, Greece, Morocco, Algeria, Egypt, Palestine, central and south Russia, Kazak, Turkestan, Semiretchje, Tadzhik, Siberia (Omsk, Tomsk, Yenisseisk), Mongolia, China, Manchuria. Oriental Region: India. Ethiopian Region: Senegal, Anglo-Egyptian Sudan, Nyasaland, South Africa (rare).

**Life History and Pathogenesis.**—The normal hosts are horses, mules, zebras, and other Equidae. The female fly larviposits into the eyes or nostrils of the host, the larvae then penetrating into the nasal cavities. According to Portchinsky, each female may produce 700 to 800 eggs, which are deposited as larvae in lots of 8 to 40 at a time. Horses are usually attacked in the autumn, the larval stage lasting through the winter; the parasitism apparently causes considerable discomfort and in severe cases may result in death.

Parasitism in man seems to be similar to that by *Oestrus ovis*, although only cases of ophthalmomyiasis have been recorded. In Russia, man may be attacked from June to September. Infestation results in a severe conjunctivitis which may last a week or more; in extreme cases, according to Portchinsky (*114*), the eye may be lost. In cases reported by Portchinsky, from 8 to 50 larvae were removed from the eye affected. As in *O. ovis*, the larvae are unable to develop beyond the first stage in this abnormal host.

**Literature.**—An extended account of this fly is given by Portchinsky (*117*). For a discussion of the first larval stage in comparison with that of *Oestrus ovis*, see Larrousse (*80*); for extensive descriptions of the third larval and of the adult stage, see Rodhain and Bequaert (*123*).

## The Family MUSCIDAE (Including the ANTHOMYIIDAE)

Although the Muscidae and Anthomyiidae probably should be considered distinct, the line between them is rather difficult to draw. For that reason the two families will be treated here under a single head. This treatment is essentially that of Curran in his "North American Diptera;" the Scopeumatidae (Scatophagidae), also in-

cluded by Curran in the Muscidae, do not fall within the scope of this work. Séguy's treatment in the "Genera Insectorum" is somewhat broader than that of this paper, since he includes the Glossinidae and Gasterophilidae. Some writers have also included the Calliphoridae in this family.

The family includes mostly dull-colored flies of medium to small size. The characters are variable; yet the family may rather readily be distinguished from the other Calypteratae. The lack of a postscutellum will readily distinguish it from the Larvaevoridae (Tachinidae); the well developed mouth parts will distinguish it from the Oestridae, Gasterophilidae, Hypodermatidae, and Cuterebridae; the lack of hypopleural bristles, or, in the few cases in which these are developed (none of the myiasis-producing species), the widely open apical cell, will distinguish it from the Calliphoridae and Sarcophagidae. The arista may be bare, pubescent, pectinate, or plumose; the eyes are widely separated in the female, moderately widely separated to contiguous in the male; the calypters are at least moderately well developed; the mesonotal suture and the postalar callus are well developed; the apical cell may vary from widely open to almost closed.

The females are usualy oviparous, though sometimes larviparous. Development is rapid. The larvae are usually of the ordinary muscoid or maggot type, the body being conico-cylindrical, greatly attenuated anteriorly; some larvae, such as *Fannia*, vary greatly from this type. The anterior spiracles typically end in a number of fingerlike processes arranged in a row; the posterior spiracles, in the third stage, are typically rounded to oval, often strongly sclerotized, with or without a peritreme, sometimes on tubercles but never in a depression or cavity.

The habits of the larvae are varied. Many are plant feeders, some are scavengers, some carnivorous, some parasitic or pseudoparasitic on invertebrates, and some parasites or scavengers in the nests of birds. Myiasis of man is more or less accidental, although it occurs frequently enough in the genera *Musca*, *Muscina*, and *Fannia* to be considered of some importance.

The family is treated in the "Genera Insectorum" by Séguy (*137*).

## KEY TO GENERA

### ADULTS

1. Anal vein attaining the posterior margin of the wing as a fold; under surface of scutellum with a number of fine erect hairs ..... 2
   Anal vein long or short, but not reaching the posterior margin of the wing even as a fold; under surface of scutellum bare ..... 4
2. Propleura hairy in the middle; grayish species with prominent velvety black markings on the thorax and abdomen ..... *Anthomyia* Meigen
   Propleura bare; uniformly grayish or dull blackish species ..... 3
3. Epistoma strongly produced beyond the vibrissal angle
   *Paregle* Schnabl and Dziedzicki
   Epistoma scarcely or not at all produced beyond the vibrissal angle
   *Hylemya* Robineau-Desvoidy
4. Arista bare or short pubescent ..... 5
   Arista long-haired, at least above ..... 8
5. Prosternum thickly pilose; vein $m_{1+2}$ strongly bowed forward and ending before the wing apex (cf. *Muscina pascuorum*, fig. 78, *B*)
   *Synthesiomyia* Brauer and Bergenstamm
   Prosternum bare; vein $m_{1+2}$ ending beyond the wing apex ..... 6

6. Second anal vein very short; the third curved forward in such a way that if the two were produced, they would intersect (fig. 71) *Fannia* Robineau-Desvoidy
Second anal vein of moderate length, the third not as above described ---- 7
7. Grayish or black species, often shining; front femur of male deformed near the apex (fig. 64) ---------- *Hydrotaea* Robineau-Desvoidy

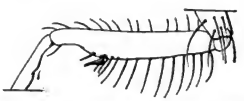

FIGURE 64.—*Hydrotaea meteorica*, inner side view of right front femur of male.

Black species, with a metallic-blue abdomen; front femur of male not deformed near the apex ---------- *Peronia* Robineau-Desvoidy
8. Arista haired above only; proboscis long, slender, shining, and rigid, with small labella (fig. 74) ---------- *Stomoxys* Geoffroy
Arista haired above and below; proboscis shorter and thicker, with large labella (fig. 81) ---------- 9
9. Vein $m_{1+2}$ broadly rounded at its bend (fig. 78); longest aristal hairs not half so long as the last aristal segment ---------- *Muscina* Robineau-Desvoidy
Vein $m_{1+2}$ angularly rounded at its bend (fig. 82); longest aristal hairs almost as long as the last aristal segment ---------- *Musca* Linnaeus

FIRST-STAGE LARVAE (AFTER TAO)

1. Larvae of the normal muscoid shape, without lateral processes ---------- 2
Larvae with prominent lateral processes ---------- *Fannia* Robineau-Desvoidy
2. Posterior end round and smooth ---------- *Musca* Linnaeus
Posterior end with papillae ---------- 3
3. Lateral plate of pharyngeal sclerites broader dorsoventrally than anteroposteriorly ---------- *Muscina* Robineau-Desvoidy
Lateral plate of pharyngeal sclerites broader anteroposteriorly than dorsoventrally ---------- *Stomoxys* Geoffroy

SECOND-STAGE LARVAE (PARTLY AFTER TAO)

1. Larvae of the normal muscoid shape, without lateral processes ---------- 2
Larvae with prominent lateral processes ---------- *Fannia* Robineau-Desvoidy
2. Posterior end round and smooth ---------- *Musca* Linnaeus
Posterior end with papillae ---------- 3
3. Lateral plates of pharyngeal sclerites very broad; the ventral horn twice as long as dorsal horn ---------- *Stomoxys* Geoffroy
Lateral plates of pharyngeal sclerites narrow; ventral horn slightly shorter than dorsal horn ---------- *Muscina* Robineau-Desvoidy

THIRD-STAGE LARVAE

1. Larvae of the normal muscoid shape, without lateral processes (fig. 83) ---------- 2
Larvae flattened, with prominent lateral processes (figs. 70 and 72) ---------- *Fannia* Robineau-Desvoidy
2. Slits of posterior spiracles strongly sinuous ---------- 3
Slits of posterior spiracles straight or arcuate ---------- 5
3. Slits of posterior spiracles each with 2 loops, S-shaped; posterior end with setulose tubercles ventrally ---------- 4
Slits of posterior spiracles each with 3 loops or more (fig. 80); posterior end smoothly rounded ---------- *Musca* Linnaeus
4. Posterior face of larvae much higher than broad; the setulose tubercles very prominent (fig. 67) slits of posterior spiracle not surrounding the button (fig. 68) ---------- *Synthesiomyia* Brauer and Bergenstamm
Posterior face of larvae not much higher than broad; the setulose tubercles only moderately prominent; slits of posterior spiracles surrounding the button (fig. 75) ---------- *Stomoxys* Geoffroy
5. Posterior spiracles oval, diverging above; their lower slit directed sharply away from the upper two (fig. 65) ---------- *Anthomyia* Meigen
Posterior spiracles rounded, with their slits not as above described ---- 6

6. Mouth hooks toothed ventrally ..... *Hylemya* Robineau-Desvoidy
Mouth hooks not toothed ventrally ..... 7
7. Slits of posterior spiracles distinctly arcuate (fig. 77)
*Muscina* Robineau-Desvoidy
Slits of posterior spiracles nearly straight (fig. 73)
*Peronia* Robineau-Desvoidy
*Hydrotaea* Robineau-Desvoidy

## The Genus ANTHOMYIA Meigen

Members of this genus are grayish or ash-colored flies with prominent velvety black markings on the thorax and abdomen. The eyes are bare; the proboscis is robust but of ordinary length; the propleura are distinctly haired; the prosternum, pteropleura, and hypopleura are bare. Vein $r_{4+5}$ is straight and the apical cell broadly open; the anal vein is continued to the wing margin as a slight but readily distinguishable fold. The scutellum bears a number of fine, pale hairs on its under surface.

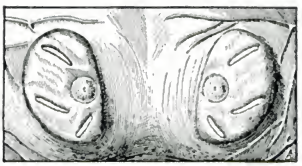

FIGURE 65.—*Anthomyia pluvialis*, posterior spiracles of puparium.

Keilin (*67*) has published an account of the biology and immature stages of two species, *A. pluvialis* (Linnaeus) and *A. procellaris* Rondani.

**Larva.**—In the two species in which the larva is known, it is of the ordinary muscoid type. The anterior end bears a series of sclerotized ridges on each side of the buccal opening, which spread out fanlike, fork, and then break up into isolated scalelike structures as they approach the dorsal side. Complete rings of small hooks are present on the anterior margin of each segment and on the posterior margin as well as on each abdominal segment. The posterior end is truncated and bears eight pairs of conical processes, each with a small sensory pit.

### ANTHOMYIA PLUVIALIS (Linnaeus)

SYNONYMY.—Some authors consider *Anthomyia procellaris* Rondani a synonym of this species; others consider the two species distinct, though closely related.

RECOGNITION CHARACTERS.—Adult: The pubescence of the arista is shorter than its basal diameter; the costal spine of the wing is but feebly developed; the thorax is grayish, with two black spots before and three behind the suture; the scutellum is black on each side at the base, but the pale gray central stripe is broad and extends from the base to the apex. Length about 5 mm. Larva: What Keilin considers as probably the larva of this species does not differ significantly from that of *A. procellaris* (fig. 65, cf. fig. 66).

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Quebec, Ontario, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Indiana, Illinois, Louisiana, Montana, Idaho, New Mexico, California. Neotropical Region: Mexico. Palaearctic Region: Scotland, England, Portugal, Spain, France, Netherlands, Italy, Capri, Corsica, Sardinia, Sicily, Malta, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Austria, Hungary, Rumania, Crete, European Russia (widespread), Azores, Canary Islands, Madeira, Morocco, Algeria, Tunisia, Dodecanese, Cyprus, Syria, Palestine, Iran, Russian Turkestan, Irkutsk, China, Japan. Oriental Region: India.

**Pathogenesis.**—Two records of myiasis caused by this species have been published, but one of these, relating to intestinal myiasis, is certainly incorrect, and the other, relating to auricular myiasis, is highly questionable. So far as known, the larvae live in birds' nests.

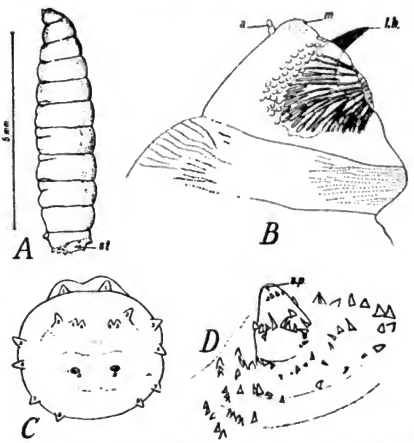


FIGURE 66.—*Anthomyia procellaris*, mature larva: *A*, lateral view; *B*, anterior end, lateral view; *C*, posterior view of last body segment, showing spiracles and eight pairs of tubercles; *D*, a tubercle, enlarged. (After Keilin (67, p. 155).)

## The Genus PAREGLE Schnabl and Dziedzicki

This genus contains several species of grayish or dull blackish Muscidae, of medium size. The epistoma is very prominent, extending somewhat beyond the vibrissal angle and forming almost a right angle with the main part of the clypeus; the propleura are bare; the scutellum is provided with some soft erect hairs on its ventral surface; the anal vein reaches to the wing margin, at least as a fold; the apical cell is broadly open; the lower calypters usually extend distinctly beyond the upper; the middle tibia bears a median anteroventral bristle.

### PAREGLE RADICUM (Linnaeus)

SYNONYMS.—*Anthomyia radicum* (Linnaeus); *Hylemyia radicum* (Linnaeus). There have been several little-used specific synonyms and other generic combinations.

RECOGNITION CHARACTERS.—Adult: This is a grayish fly, usually with the anterior half of the frontalia of the female conspicuously orange. The acrosticals are irregularly paired, with numerous accessory setulae between the rows; the lower calypters protrude distinctly beyond the margin of the upper; the hind tibia has three posterodorsal and five to eight anterodorsal bristles. The legs are black. Length about 5 mm.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Greenland, Alaska, Labrador, North Canada (Akpatok Island, Ungava Bay), New Brunswick, Quebec, Ontario, Manitoba, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, District of Columbia, Indiana,

Illinois, Minnesota, Wisconsin, Kansas, Idaho, Colorado, Washington. Palaearctic Region: Ireland, Scotland, England, Spain, France, Netherlands, Italy, Corsica, Sicily, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Austria, Hungary, Rumania, European Russia (north to Kanin Peninsula), Novaya Zemlya, Azores, Algeria, Libia, Siberia (Irkutsk, Yana Valley), Kamchatka, China. Australian Region: Victoria.

**Biology and Pathogenesis.**—This species breeds in various media, including grasses and small grains, roots of cabbage and radishes, horse manure, and decomposing vegetable matter.

Several cases of intestinal myiasis caused by this species have been reported. One which seems to be authentic was reported by Austen (*5*), who made determinations on the flies reared from larvae passed over a period of several days by an otherwise healthy child.

### The Genus HYLEMYA Robineau-Desvoidy

The larvae of this genus very commonly feed on a wide range of plants used for food, including roots that may be eaten raw. It is highly probable that from time to time living larvae may be ingested, though there is no proof of their ability to cause digestive disturbances or to survive the conditions found in the human digestive tract. Some members of this genus, such as *H. furcata* (Bouché), *H. brassicae* (Bouché), and *H. antiqua* (Mg.) (*H. ceparum* (Mg.)), have been mentioned in connection with intestinal myiasis, but confirmation of the records is lacking.

### The Genus SYNTHESIOMYIA Brauer and Bergenstamm

This genus contains but a single species. The arista is bare; the propleura and pteropleura are bare, the prosternum distinctly pilose; there are two presutural and four postsutural dorsocentrals; there are three sternopleurals, the lower one being situated very close to the hind one; the metathoracic spiracle is much longer than broad; the wing veins are bare above and below; vein $m_{1+2}$ bows strongly forward, as in *Muscina*, and reaches the costa before the wing apex; the anal vein is long but does not attain the wing margin, even as a fold.

#### SYNTHESIOMYA NUDISETA (van der Wulp)

Synonyms.—*Synthesiomyia brasiliana* Brauer and Bergenstamm; *Synthesiomyia analis* (Macquart).

Recognition Characters.—Adult: This is a grayish fly, about 10 mm. in length, with a striped thorax, a somewhat tesselated abdomen which is yellow at the apex, and bright orange-yellow antennae and palpi. Superficially it resembles a *Sarcophaga*, but the bare arista and the lack of hypopleural bristles will at once distinguish it from members of that genus. Larva: The larva is of the usual muscoid type. In the first instar there are characteristic tubercles on the eighth abdominal segment; one is median, posterior to the anus, and spined; there are three pairs of unspined tubercles in a ventrolateral position. In the second instar the tubercles are more prominent and all are spined. The third-stage larva is 7–15 mm. in length, is relatively thick, and creamy white. The spinulose tubercles are prominent; in addition, there are six larger and two smaller sensory papillae surrounding the spiracles (fig. 67). The posterior spiracles are black and prominent (fig. 68); they have no peritreme, and the slits are S-shaped; the button is difficult to distinguish. The anterior spiracles have four to seven processes.

Geographical Distribution.—Nearctic Region: North Carolina, Georgia, Florida, Texas, Arizona. Neotropical Region: Mexico, Nicaragua, Costa Rica, Panama, Canal Zone, Bermuda, Dominican Republic, Cuba, Virgin Islands, Gala-

pagos Islands, Ecuador, Brazil, Peru, Bolivia, Paraguay, Chile, Argentina. Palaearctic Region: Canary Islands, Madeira. Oriental Region: India. Ethiopian Region: Zanzibar, South Africa (Transvaal, Natal), Seychelles. Australian Region: Queensland, Wake, Samoa, Fiji, Society Islands (Tahiti), Hawaiian Islands.

**Biology and Pathogenesis.**—The larvae breed in various animal and vegetable materials, such as human and animal cadavers, decayed cotton seeds, dead locusts, feces, and kitchen refuse. Development is rapid; the third larval instar may be attained within 3 days after oviposition, and the complete life cycle may be completed in less than 3 weeks. Pupation takes place in the soil within a cocoon formed of sand grains cemented together.

This species has been recorded as involved in secondary wound myiasis. It is probably of little importance.

**Literature.**—Siddons and Roy (*140*) give an account of the life history and immature stages.

## The Genus FANNIA Robineau-Desvoidy

The generic name *Homalomyia* has been used in much of the older literature on this genus.

These are medium to small-sized flies; the eyes are large, the cheeks consequently narrow; the proboscis is short. There are two presutural and three postsutural dorsocentrals and two rows of acrosticals. Vein $m_{1+2}$ runs straight to the margin, the apical cell consequently being wide open; the second anal vein is short, the third curved strongly forward in such a way that, if the two were prolonged, they would intersect (fig. 71).

FIGURE 67.—*Synthesiomyia nudiseta*, posterior view of last body segment of mature larva.

**Life Histories.**—The eggs, which are provided with two broad sclerotized expansions, are deposited on the medium in which the larva is to live. There are three larval stages. In the species for which the life histories have been worked out, development is rapid when conditions are favorable, and there may be two or more generations a year. The larvae breed in vegetable and animal matter in a somewhat advanced state of decomposition, cadavers, excrement, fermenting foods, and rubbish in the nests of birds and Hymenoptera; sometimes they may parasitize insects or vertebrates, although in the vertebrates parasitism is accidental and in insects it is doubtful whether it may be considered true parasitism. The mature larva leaves the semiliquid habitat to pupate.

**Larva.**—The larva is of characteristic form; the body is flattened, narrowed anteriorly, and becoming broadest on the abdominal segments; each segment beyond the first bears, on each side, a prominent lateral process (usually longer on the posterior segments) which may be either simple or pectinate; the last segment bears three such processes; a row of similar but less prominent processes occurs on the upper part of the ventral surface below this later row; these processes are missing on the last segment; other usually less prominent but often

characteristic processes, or rudiments of them, may occur dorsally or ventrally. These processes, in some species, act as organs of flotation, and are adaptive to life in a semiliquid medium; they were mistaken for gills by earlier authors. The first (prothoracic) segment bears a pair of antennalike processes. The head is very small; the anterior spiracles are rather prominent and ending in a number of digitate processes; the posterior spiracles are more or less elevated and three-lobed, each lobe containing an opening.

**Pathogenesis.**—There are on record numerous cases of parasitism of the digestive and urinary tract of man by several species of *Fannia*. When present in the stomach, the larvae may cause vertigo, nausea, and violent pains; they may be expelled by vomiting. In the intestine they may produce abdominal pains, diarrhea, and sometimes

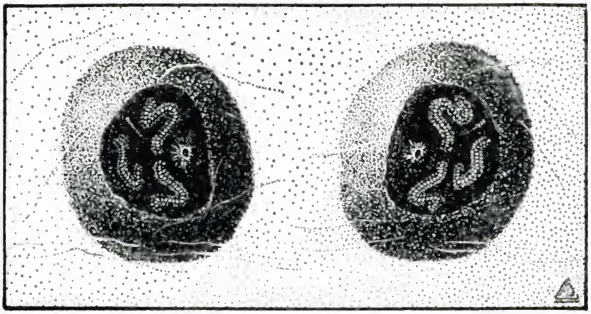

FIGURE 68.—*Synthesiomyia nudiseta*, posterior spiracles of mature larva.

hemorrhage resulting from the lesions of the intestinal mucous membrane. The patient will sometimes complain of disagreeable epigastric feelings of a tremulous nature. The abdomen may be swollen. Loss of sleep and appetite and general weakening may result. Intestinal myiasis is diagnosed by the recovery of larvae in stools; in severe cases a quart or more of larvae may be passed, and the period of expulsion may extend over several months.

A number of records of myiasis of the urinary passage and bladder are on hand. Some of these are doubtful, but a sufficiently large number are well authenticated. The usual symptoms consist of difficulty and pain in urination; the number of parasites is generally small, and when they are passed, relief is obtained. In one case, cited by Mumford (*91*), a heavily parasitized 1-year-old boy became seriously ill, with convulsions; however, he recovered when the maggots had been passed.

Infestation may come from food eaten in the raw state, or the eggs may be deposited on or near the anus, where the maggots, after hatching, may make their way into the urinary tract or intestine. Such an infestation may result from the use of unsanitary open privies, from unsanitary care of small children, or from sleeping with the body exposed in warm weather in places where flies are abundant.

The flies may be attracted by odorous discharges, especially those of an albuminous nature.

Different species of *Fannia* may be associated with each other or with *Musca domestica* in individual cases. *Fannia canicularis* has also been known to be present, along with other muscoids, in wound myiasis in monkeys.

**Literature.**—For the identification of the Palaearctic species, the keys of Séguy (*133, pp. 259–268*) for France, and of Karl (*63*) for Germany, will be useful. Malloch (*86*) has given keys for the determination of the Nearctic species. Important works on the biology, immature stages, and role in myiasis are Hewitt (*58, p. 171*), Mazza and coworkers (*87*), Lampa (*79*), and Mumford (*91*).

## KEY TO SPECIES

### ADULTS

1. Males: Eyes separated by no more than the width of the third antennal segment, often contiguous ..... 2
   Females: Eyes separated by several times the width of the third antennal segment ..... 5
2. Middle coxa on the anterior surface with one or more stout thorns which are directed downward and angularly bent at the apex (fig. 69); abdomen black in ground color ..... 3

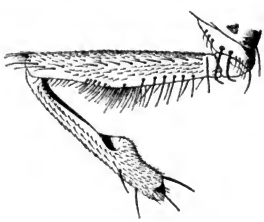

FIGURE 69.—*Fannia scalaris*, middle leg, exclusive of tarsus, of male.

   Middle coxa without thorns as above-described, merely with bristles of the usual form and strength ..... 4
3. Middle tibia strongly expanded into a deformed tubercle ventrally beyond the middle (fig. 69); grayish species; usually 2 bent thorns on the middle coxa ..... *scalaris* (Fabricius), male
   Middle tibia moderately thickened beyond the middle, but not tuberculate or deformed; blackish species; usually 1 bent thorn on the middle coxa ..... *manicata* (Meigen), male
4. Hind tibia with several rather closely placed long hairlike bristles on the middle of the anteroventral, posteroventral, and anterior surfaces; abdomen black in ground color ..... *incisurata* (Zetterstedt), male
   Hind tibia with 1 to 4 short bristles on the anteroventral surface, the other ventral surfaces bare; second and third abdominal tergites largely pellucid yellow ..... *canicularis* (Linnaeus), male
5. Mesonotum with 3 brownish vittae, the middle one at least distinct; abdomen usually more or less extensively yellow at the base. *canicularis* (Linnaeus), female
   Mesonotum sometimes with paired, but not with a median, vitta; abdomen wholly black in ground color ..... 6

6. Thorax gray, with more or less distinct traces of 2 to 4 vittae; anterior tibia with a small but distinct anterodorsal bristle somewhat basad to the preapical one ..... 7
Thorax blackish gray, without traces of vittae; anterior tibia without a smaller anterodorsal bristle basad to the preapical one.
*manicata* (Meigen), female
7. Ocular orbits and mesonotum densely grayish pollinose; middle femur with an outstanding, though rather slender, bristle at the base below.
*scalaris* (Fabricius), female
Ocular orbits and mesonotum sparsely grayish pollinose; middle femur with only a short fine hair below at the base.
*incisurata* (Zetterstedt), female

THIRD-STAGE LARVAE

1. Lateral processes of the abdominal region spinulose only on the basal region, not pinnate; dorsal processes similar in nature to and almost as long as the lateral ones ..... *canicularis* (Linnaeus)
Lateral processes pinnate at least almost to the apex; dorsal processes less than half the length of the lateral ones ..... 2
2. Dorsal processes well developed, though small, and spinulose.
*scalaris* (Fabricius)
Dorsal processes reduced to sclerotized buttons, scarcely or not at all evident ..... 3
3. Lateral processes large and strongly developed, the branches of adjacent ones touching, or almost so ..... *incisurata* (Zetterstedt)
Lateral processes relatively small, the branches of adjacent ones not nearly touching ..... *manicata* (Meigen)

## FANNIA SCALARIS (Fabricius)

The Latrine Fly

SYNONYMS.—*Homalomyia scalaris* (Fabricius); *Fannia saltatrix* Robineau-Desvoidy.

RECOGNITION CHARACTERS.—Adult: This is a slender fly, about 6–7 mm. in length; the body is black, the legs likewise black except the knees and the bases of the front tibiae. The parafrontals and parafacials are silvery; the thorax and abdomen gray-dusted, the former with two brownish vittae, the latter with a black median band. Larva (fig. 70): The antennalike processes of the prothoracic segment are very short; the lateral processes of the other segments are long and pinnate to their apices, their length increasing progressively backward. Dorsally, the segments of the thorax, except the first, each bear a pair of short spinous tubercles; the segments of the abdomen, except the last, have similar but more strongly developed processes. The anterior spiracles end in six to eight, usually seven digitate processes. The length of the mature larva is about 6 mm.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Labrador, Nova Scotia, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Tennessee, Indiana, Iowa, South Dakota, Kansas, Texas, Montana, Idaho, Colorado, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Chile, Argentina. Palaearctic Region: Ireland, Scotland, England, Spain, France, Netherlands, Belgium, Italy, Corsica, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Poland, Austria, Hungary, Yugoslavia, Rumania, European Turkey, European Russia (widespread), Caucasus, Azores, Canary Islands, Morocco, Palestine, Russian Turkestan, Manchuria, Chosen, Japan. Ethiopian Region: South Africa.

**Life History and Pathogenesis.**—The larvae have been recorded as breeding in decaying fungi, cadavers, birds' nests, nests and burrows of Hymenoptera, and excrement. They are common in privies, and Lesne (*82*) records them as common, though not nearly so much as *F. incisurata*, in cesspools in the vicinity of Paris. The eggs hatch in a short time, often 2 days or less; the life cycle in temperate climates

in midsummer can be completed in a month or less. A number of cases of intestinal and vesicular myiasis are on record, and the species has been recorded in aural myiasis.

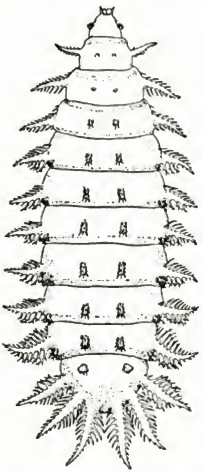

FIGURE 70.—*Fannia scalaris*, mature larva. (After Hewitt (*58, p. 165*).)

**Literature.**—An account of the immature stages, biology, and pathogenesis is given by Hewitt (*58, p. 168*).

### FANNIA MANICATA (Meigen)

SYNONYM.—*Homalomyia manicata* (Meigen).

RECOGNITION CHARACTERS.—Adult: This is a blackish species with wholly black legs; the thorax lacks pale pollen; the abdomen, especially in the male, has more or less grayish pollen, with a distinct median stripe of black; the general appearance is that of a species darker than the preceding one. Length about 5–7 mm. Larva: The larva is similar to that of *F. scalaris*, but the lateral processes are smaller and the dorsal processes are reduced to small buttons which are scarcely or not at all visible.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alaska, Quebec, Ontario, Alberta, New Hampshire, New York, New Jersey, Maryland, Ohio, Kansas, Arizona, Washington, Oregon. Palaearctic Region: Scotland, England, France, Netherlands, Corsica, Sweden, Finland, Lapland (Swedish), Germany, Austria, European Russia, Egypt, Kamchatka.

**Life History and Pathogenesis.**—This species has been recorded from nests of Hymenoptera, decomposing fungi, and other decaying plant and animal material. Lampa (*79*) describes a case of intestinal parasitism due to this species in association with two others, and gives an account of its biology and immature stages.

### FANNIA INCISURATA (Zetterstedt)

SYNONYM.—*Homalomyia incisurata* (Zetterstedt).

RECOGNITION CHARACTERS.—Adult: This is a blackish species, with brownish to blackish legs; the parafacials and parafrontals are lightly dusted with grayish pollen; the thorax has two brownish longitudinal vittae; the abdomen is gray pollinose, with a black median vitta. Length 6–7.5 mm. Larva: The larva is similar to that of *Fannia scalaris*, but the body is larger, more depressed, and paler, often of a vitelline yellow; the lateral body processes are longer, their fringes almost filling the intervals between them; and the dorsal processes are reduced to chitinous buttons and are scarcely visible.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Jan Mayen, Quebec, Manitoba, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, District of Columbia, Virginia, Minnesota, Idaho. Neotropical Region: Mexico, Argentina. Palaearctic Region: Iceland, Scotland, England, Spain, France, Netherlands, Italy, Corsica, Malta, Sweden, Finland, Germany, Austria, European Russia, Canary Islands, Madeira, Tangier, Libia, China, Japan.

**Life History and Pathogenesis.**—The life history is similar to that of *F. scalaris*. The larvae, with their more strongly developed flotation apparatus, are better adapted to life in a semiliquid medium. Lesne found this by far the most abundant species breeding in cess-

pools in the vicinity of Paris. It has been recorded from excrement, cadavers, and the nests of birds and of Hymenoptera.

This species has been recorded several times as involved in intestinal and aural myiasis.

**Literature.**—An account of the biology and life history is given by Lesne (*82, p. 56*).

## FANNIA CANICULARIS (Linnaeus)

The Lesser Housefly

Fig. 71

SYNONYM.—*Homalomyia canicularis* (Linnaeus).

RECOGNITION CHARACTERS.—Adult: This is a slender fly, in large part blackish, but with the abdomen usually more or less extensively yellow, the yellow regions

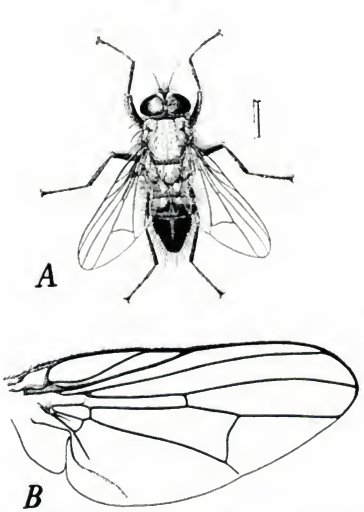


FIGURE 71.—*Fannia canicularis: A*, Adult male; *B*, wing.

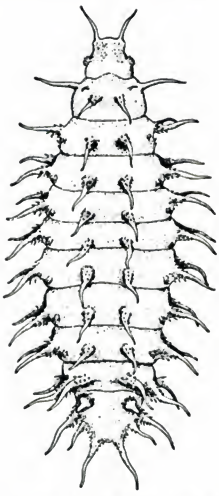

FIGURE 72.—*Fannia canicularis*, mature larva. (After Hewitt (*58, p. 164*).)

being especially prominent in the male and characteristically in the form of three, sometimes four, pairs of spots. The middle tibia of the male is not deformed. The thorax has three brown stripes, which are fairly evident in unrubbed specimens. Length about 6–7 mm. Larva (fig. 72): The antennalike processes of the prothoracic segment are long and prominent; the lateral processes are not pectinate, but are spinose on their basal region only; the dorsal processes are similar to the lateral ones and almost as large. The anterior spiracles have five to eight, usually seven, processes; the posterior spiracles are longer and more prominent than in *F. scalaris*. Length 5–6, sometimes up to 8 mm.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Greenland, Alaska, Nova Scotia, Quebec, Ontario, Alberta, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Florida, Alabama,

Mississippi, Tennessee, Ohio, Michigan, Illinois, Minnesota, Iowa, South Dakota, Kansas, Texas, Montana, Idaho, Colorado, Utah, New Mexico, Arizona, California. Neotropical Region: Mexico, Guatemala, Costa Rica, Colombia, Galapagos Islands, Brazil, Peru, Uruguay, Chile, Argentina, Patagonia, Falkland Islands. Palaearctic Region: Iceland, Faeroes, Ireland, Scotland, England, Portugal, Spain, France, Netherlands, Italy, Corsica, Sicily, Malta, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, Greece, European Turkey, European Russia, Azores, Canary Islands, Madeira, Morocco, Algeria, Libia, Egypt, Kamchatka, China, Manchuria, Chosen, Japan. Ethiopian Region: Zanzibar, Southern Rhodesia, South Africa (Transvaal, Natal, Cape of Good Hope). Australian Region: Western Australia, New South Wales, New Zealand, New Guinea, Hawaiian Islands, Antarctic Islands.

**Life History and Pathogenesis.**—The breeding habits of this fly are extremely varied. It is common in excrement, human and animal, though, according to Lesne, it does not breed in cesspools in the vicinity of Paris. It has been reported from decaying vegetable matter (onions, fungi), from dead insects, from vertebrate cadavers, from birds' nests, from the nests of Hymenoptera, and from food substances, such as fruits, smoked or salted meats, and cheese and other milk products. It has been reported as a parasite of Orthoptera, Coleoptera, and snails; in at least some of these cases, however, it may have been living as a saprophyte. The adults frequent houses, but in smaller numbers than houseflies. The life cycle, in midsummer in temperate climates, may be completed in a month or less.

The larva, often in association with other species, has been recorded a number of times in intestinal myiasis; it is the most common cause of vesicular myiasis. Two cases of cutaneous myiasis in monkeys have been reported. In one, recorded by Carter and Blacklock (*24*), the maggots, in association with those of *Calliphora vicina* (*erythrocephala*) and *Muscina stabulans*, were found in wounds in the mouth and nasal region and on the abdomen of a monkey dying of tuberculosis; the other case was recorded by Séguy, without details. It has also been recorded in aural myiasis.

**Literature.**—An account of the immature stages, biology, and pathogenesis is given by Hewitt (*58, p. 162*); a detailed description of the larva and of urinary myiasis caused by it is given by Chevrel (*27, pp. 393–414*).

### FANNIA FUSCONOTATA (Rondani)

GEOGRAPHICAL DISTRIBUTION.—Neotropical Region: Argentina.

**Pathogenesis.**—A case of vesicular myiasis was caused by a larva questionably identified as this species. No adults were reared. The patient suffered abdominal pains, malaise, low fever, and difficulty in urination; small quantities of blood were passed with the urine. An account of the case, with a description and photographs of the larvae, is given by Mazza and coworkers (*87*).

### FANNIA LEYDII (Walsh)

### FANNIA WILSONI (Walsh)

These species were described from larvae obtained from cases of intestinal myiasis in Illinois. No adults were reared, and it is doubtful whether the identity of the species can ever be determined.

## The Genus HYDROTAEA Robineau-Desvoidy

The following characters will merely aid in a recognition of this genus; for a more positive determination it will be best to consult a more comprehensive key to the genera of Anthomyiidae.

The eyes are contiguous in the males; in the females the front is broad and cruciate frontals are present. In the species considered here, there are two presutural dorsocentrals, two sternopleurals and no hypopleurals; the hind tibia has only one anterodorsal bristle in addition to the preapical one. Vein $m_{1+2}$ runs straight to the margin, the apical cell consequently being broadly open; the second anal vein is of moderate length, not reaching the wing margin; the third anal is short. In the male the front femur is excavated below near the apex, with a tooth basad of the excavation (fig. 64).

**Life Histories.**—Comparatively little information is available. The larvae live in excrement or in partially decomposed vegetable matter; several species have been reared from birds' nests. The larvae are at first saprophagous, although in the third stage they may become carnivorous and feed on other dipterous larvae. In several species the adults, especially the females, annoy man and cattle by persistently alighting on their bodies in search of sweat or blood drawn by bloodsucking flies.

**Larva.**—The larva of only one species, *H. dentipes* (Fabricius), has been described (Keilin *66, p. 399*); it is of the usual muscoid type.

### HYDROTAEA METEORICA (Linnaeus)

Recognition Characters.—Adult: This is a black species, about 4 to 6 mm. in length. The thorax is shining in the male, ashy gray in the female; the abdomen is gray pollinose, with a median black band formed from connected triangles. The eyes in the male are narrowly separated. The wings are lightly infumated; the halteres black.

Geographical Distribution.—Nearctic Region: Quebec, Alberta, Maine, Vermont, Connecticut, New York, Maryland, North Carolina, Indiana, Illinois, North Dakota, South Dakota, Montana, Idaho, Colorado, New Mexico, Washington, California. Palaearctic Region: Ireland, Scotland, England, France, Netherlands, Corsica, Sweden, Finland, Germany, Austria, Russia.

**Biology and Pathogenesis.**—No details of life history are known. Two records of intestinal myiasis have been published; in one a blacksmith, after several months of illness, passed a quantity of larvae from which adults were reared; in the other about 60 larvae, said to be this species, were recovered from stools of children suffering from dysentery. This species has also been recorded in aural myiasis.

## The Genus PERONIA Robineau-Desvoidy

There is but one species known in this genus.

### PERONIA ROSTRATA Robineau-Desvoidy

Recognition Characters.—Adult: This is a black fly, about 6–7 mm. in length; the abdomen is metallic blue, the color being especially noticeable from the posterior view; the last abdominal segment is covered with an ashy-gray pollen. The epistoma is strongly produced; the hypopleura bear some strong hairs below and in front of the spiracle. Larva: This is a smooth maggot of the ordinary muscoid type; for the structure of the posterior spiracles, see figure 73.

Geographical Distribution.—Australian Region: Recorded from every state in Australia but evidently limited to that continent.

FIGURE 73.—*Peronia rostrata*, posterior spiracles of pupa.

**Pathogenesis.**—Probably of no medical importance. It is known to be a tertiary sheep maggot, but it does not invade healthy tissue.

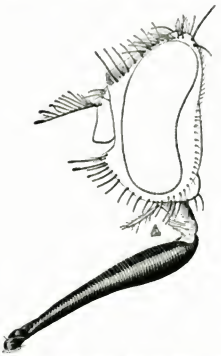

FIGURE 74.—*Stomoxys calcitrans*, head of female, side view.

## The Genus STOMOXYS Geoffroy

The genus is treated here in its more restricted sense; some authors, such as Patton and Zumpt, extend it to include the horn flies and their relatives.

*Stomoxys* is easily distinguished from other Muscidae by the following combination of characters: The proboscis is long and slender, broader at its base and narrowing toward the apex; it is horny, shining, and rigid, with small, inconspicuous labella, and is fitted for piercing and sucking blood (fig. 74). The palpi do not extend beyond the middle of the haustellum. The antennal arista is pectinate, with no rays below.

FIGURE 75.—*Stomoxys calcitrans*, posterior spiracles of pupa.

The genus includes a number of species of grayish flies of medium size that resemble the housefly in appearance. *S. calcitrans* (L.) is almost cosmopolitan and is the only species occurring in the New World, Australia, and much of the Palaearctic Region.

**Life Histories.**—The females are oviparous. The larvae shun light, which is detrimental to them. They breed in the excrement of many animals, horse manure being favored; they have also been reported as breeding in birds' nests and in decaying vegetable matter. The adults, both males and females, are savage biters, but attack horses and other domestic animals in preference to man.

**Larvae.**—The first-stage maggot is whitish, translucent, and about 2 mm. long. The mature larva is of the ordinary muscoid type, with the posterior end distinctly broader than the anterior; the posterior spiracles (fig. 75) are rather small and widely separated, with three strongly sinuous openings; the rather poorly defined button is in the middle.

**Literature.**—For a key to the species of the world and a discussion of the biology see Séguy (*136*); for a discussion of the medical importance see Zumpt (*160*).

### STOMOXYS CALCITRANS (Linnaeus)

The Stablefly; the Biting Housefly

Recognition Characters.—Adult: This is a grayish to black fly, about 5 or 6 mm. in length; the pollen of the thorax and abdomen is mainly gray, but there are four vittae of brownish pollen on the thorax and spots of pollen of the same color on the abdomen, those of the intermediate segments being in the form of a single spot at the base and a pair at the apex of each segment. The legs are black, with more or less yellow on the tibiae. The front tarsus of the male lacks fine, erect hair on the anterior surface. Larva: Too little is known of the larvae of this genus to enable one to give specific characters.

Geographical Distribution.—Nearctic Region: Alaska, Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, United States (records from every state and the District of Columbia). Neotropical Region: Mexico, Guatemala, Honduras, Costa Rica, Panama, Canal Zone, Bermuda, Bahama Islands, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Antigua, St. Vincent, Barbados, Grenada, Trinidad, Colombia, Galapagos Islands, Ecuador, Venezuela, British Guiana, Brazil, Peru, Bolivia, Chile, Argentina, Patagonia. Palaearctic Region: Scotland, England, Portugal, Spain, France, Netherlands, Belgium, Switzerland, Italy, Corsica, Sardinia, Sicily, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Austria, Hungary, Yugoslavia, Rumania, Greece, European Turkey, Russia (widespread), Azores, Canary Islands, Madeira, Morocco, Algeria, Libia, Egypt, Turkey (Asiatic), Dodecanese, Palestine, Arabia, Iraq, Iran, Asiatic Russia (widespread), China, Chosen, Japan. Oriental Region: India, Ceylon, Burma, Thailand, Indo-China, Federated Malay States, Taiwan, Philippine Islands, Sumatra, Java, Celebes. Ethiopian Region: Gambia, Guinea, Sierra Leone, Ivory Coast, Gold Coast, Nigeria, Sudan, Eritrea, Ethiopia, Belgian Congo, Angola, Uganda, Kenya, Tanganyika, Zanzibar, Nyasaland, Mozambique, Rhodesia, South Africa (Transvaal, Basutoland, Zululand, Cape of Good Hope), Madagascar, Seychelles, Mauritius. Australian Region: Australia (every state), Tasmania, New Zealand, New Caledonia, Guam, Samoa, Fiji, Hawaiian Islands.

**Biology and Pathogenesis.**—The eggs hatch in 1 to 3 days. The larva completes its development in 11 to 30 days, depending on the food and physical conditions of the environment; the pupal period, in the summer, lasts 6 to 20 days. The rate of development is much slower than that of the housefly. In cooler climates hibernation takes place in the larval or pupal stage; in warmer climates there is no true hibernation.

Zumpt (*160*) briefly discusses the three recorded cases of myiasis supposedly caused by this fly, and concludes that the records were probably erroneous. However, the subject cannot be dismissed so lightly. In the case reported by Porter (*119, p. 377*) an adult was reared from larvae obtained from the neglected foot of a native stable boy in South Africa; and Knipling and Rainwater (*75*) have recorded this species from wounds in an unspecified domestic animal. As to intestinal myiasis, Onorato (*96*) describes a case in which maggots were expelled in the vomit of a boy in Tripolitania, in the presence of a physician, and 25 of them were reared to the adult stage. It would seem, then, that this species may, on rare occasions, produce both gastric and traumatic myiasis.

## The Genus MUSCINA Robineau-Desvoidy

The genus *Muscina* may be distinguished from other common Muscidae by the following combination of characters: The body is robust, brownish or black in ground color, with rather dense grayish pollen, which, on the abdomen, is changeable with the light incidence; the apex of the scutellum is more or less extensively reddish or yellow; the arista is long plumose; the proboscis is short and the labella fleshy; the eyes are bare; the wings are uniformly hyaline, without noticeable yellowing at the base; vein $m_{1+2}$ is distinctly bowed forward, but the bow is broad and not sharply bent; anterior acrosticals are present in two rows; and the pteropleura are bare. The adults bear some superficial resemblance to certain Sarcophagidae, but the lack of hypopleural bristles will at once distinguish them.

**Life Histories.**—The adults feed on various substances, but chiefly juices from meats, fruits, and vegetables which are spoiling or fermenting. The larvae breed in various types of media, including fungi, decaying or diseased vegetable matter, bodies of dead insects, snails, and vertebrates, and, as parasites, on living insects and vertebrates. Several species attack nestling birds. In their food habits they are characterized in Keilin (*66, p. 437*) as omnivorous and are considered by him as transitional between the saprophagous and the truly parasitic muscids, such as *Passeromyia*.

FIGURE 76.—*Muscina stabulans*, first-stage larva. After Séguy (*134, p. 312*).)

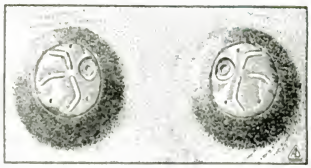

FIGURE 77.—*Muscina stabulans*, posterior spiracles of puparium.

Eggs are deposited upon the breeding medium. There are three larval stages; in the last stage, the larvae become highly voracious and carnivorous, and destroy other dipterous larvae with which they come in contact. Pupation occurs within a cocoon formed from debris surrounding the transforming larva.

**Larva.**—The larva is of the usual muscoid type, slender and pointed anteriorly, and gradually broadening posteriorly. The first-stage larva (fig. 76) is translucent, its internal organs being clearly visible through the integument; it is smooth and glabrous, without complete rows of spinules, but with small ventral spinulose areas anteriorly on at least most of the abdominal segments. The mouth is surrounded

by denticles, and the posterior end is papillated. The second larval stage is similar to the first, except for the usual changes in the posterior spiracles and the development of anterior ones. The third-stage larva has characteristic posterior spiracles (fig. 77); the peritreme is very thick and the three slits are arcuate; beside the slits, there are four feebly sclerotized areas, each bordered outwardly by a fanlike fringe of hairs; each anterior spiracle ends in four to six fingerlike processes.

**Pathogenesis.**—Most species of *Muscina* are saprophytic, at least in the earlier stages. The only species known to be involved in the production of myiasis in man is *M. stabulans;* in man, it has been recorded only as an intestinal parasite, although it has been known to produce wound myiasis in animals.

## KEY TO SPECIES

The following key will separate the four most common *Muscina* species of the Holarctic Region. The other species of this region and the rest of the world are either of doubtful validity or of uncommon occurrence.

ADULTS

1. Tibiae yellow ..... *stabulans* (Fallén)
   Legs entirely black ..... 2
2. Palpi black; vein $m_{1+2}$ but slightly curved upward (cf. *stabulans*, fig. 78, *A*) ..... *assimilis* (Fallén)

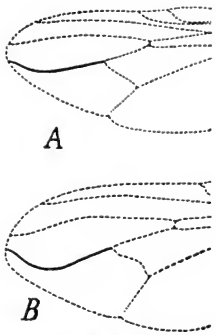


FIGURE 78.—Venation of apical half of wing: *A*, *Muscina stabulans;* *B*, *M. pascuorum*

   Palpi yellow; vein $m_{1+2}$ strongly curved upward (fig. 78, *B*) ..... 3
3. Abdomen without a trace of red laterally; grayish pollen abundant, especially on the thorax ..... *pabulorum* (Fallén)
   Abdomen usually brownish red at the base laterally; body with bluish reflections and without abundant grayish pollen ..... *pascuorum* Linnaeus

## MUSCINA STABULANS (Fallén)

The False Stablefly

RECOGNITION CHARACTERS.—Adult: The body is largely black, covered with thick grayish pollen; the abdomen may be more or less reddish on the sides, or may be entirely black; and the scutellum is broadly reddish at the apex. The first two segments of the antennae and the base of the third are largely red. The palpi, tibiae, and about the apical half of the femora are yellow. Vein $m_{1+2}$

bends rather feebly upward, meeting the costa before the wing apex. Length, about 8 mm. Larvae: It is difficult to distinguish the larvae from that of *M. assimilis*, the only known characters for their separation being the structure of the buccopharyngeal armature (fig. 79.) The newly hatched larva measures about 1.5 mm.; the mature third-stage larva, about 12–18 mm. in length by 5–6 mm. in width. The mature larva is creamy to grayish white; its skin is rather tough, but not so tough as in most carnivorous larvae; the mouth hooks are stouter than those of *M. assimilis*.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Alaska, Nova Scotia, New Brunswick, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey,

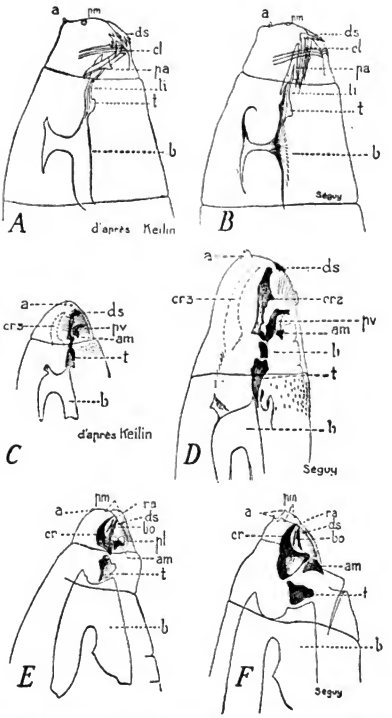


FIGURE 79.—Anterior segments of larva of *Muscina*, side view: *A*, *M. assimilis* first stage; *B*, *M. stabulans*, same; *C*, *M. assimilis*, second stage; *D*, *M. stabulans*, same; *E*, *M. assimilis*, third stage; *F*, *M. stabulans*, same. (After Séguy (*134*, *p. 443*), and Keilin (*66*).)

Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Ohio, Michigan, Indiana, Illinois, Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Kansas, Arkansas, Texas, Montana, Idaho, Colorado, Utah, New Mexico, Washington, Oregon, California. Neotropical Region: Mexico,

Guatemala, Brazil (São Paulo), Peru, Chile, Argentina, Patagonia. Palaearctic Region: Ireland, Scotland, England, Spain, France, Netherlands, Italy, Corsica, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, European Turkey, Russia (widespread), Azerbaijan, North Caucasus, Azores, Canary Islands, Madeira, Morocco, Algeria, Tunisia, Libia, Egypt, Syria, Palestine, Siberia (Tomsk, Kamchatka), China, Manchuria, Chosen, Japan. Oriental Region: Taiwan, India. Ethiopian Region: Tanganyika, Kenya, Southern Rhodesia, South Africa (Transvaal). Australian Region: South Australia, Queensland, New South Wales, Canberra, New Zealand, New Hebrides (Espiritu Santo Island).

**Biology and Pathogenesis.**—The females frequently enter houses and may oviposit on foods, particularly those that are slightly tainted; it is probably in this way that man occasionally becomes parasitized. Each female may produce 140 to 200 eggs, which she scatters over the food substratum. The first larval stage is of very brief duration, the second somewhat longer, and the third, in which the carnivorous habit becomes the most highly developed, is by far the longest. The length of the larval life is from 15 to 25 days; higher temperatures and an abundance of animal food will make it tend toward the lower figure. Several generations may be produced in a summer. Normally, hibernation takes place in the pupal stage, although larvae produced late in the season, if they survive, may remain dormant over the winter. A similar period of semidormancy may explain some of the protracted cases of intestinal parasitism in man.

A number of cases of human intestinal myiasis have been recorded. One of these, described by Portchinsky (*115*), lasted from November to the following March, all the time causing great pain, sickness, and vomiting. The ill effects, which have been described (Portchinsky) as similar to "false typhus," may be due to the tearing of the mucous lining of the intestine by the mouth hooks, with the resulting loss of blood and entrance of toxic products into the wounds.

Carter and Blacklock (*24*) described a case of cutaneous myiasis, involving the mouth and nasal region, as well as a body wound, in a monkey dying of acute tuberculosis, and Séguy has demonstrated the experimental production of myiasis in wounds in rabbits, guinea pigs, and hedgehogs. Nestling birds may be parasitized by this species, with fatal results.

**Literature.**—Important papers on the biology, larval structure, life history, and role in myiasis are Portchinsky (*115*), Keilin (*66, p. 415*), and Séguy (*134*).

### MUSCINA ASSIMILIS (Fallén)

Geographical Distribution.—Nearctic Region: Alaska, Newfoundland, New Brunswick, Quebec, Manitoba, Alberta, British Columbia, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, District of Columbia, Virginia, North Carolina, Tennessee, Ohio, Indiana, Illinois, Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Montana, Idaho, Colorado, Utah, Nevada, New Mexico, Oregon, California. Neotropical Region: Mexico. Palaearctic Region: England, Portugal, Spain, France, Netherlands, Italy, Corsica, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Austria, Rumania, Russia (north to Arkhangelsk), North Caucasus, Azores, Canary Islands, Palestine, Siberia (Kamchatka), Japan.

**Pathogenesis.**—This species is known to produce at times a fatal myiasis in nestling birds. Adults do not usually enter houses; therefore, the contact necessary for causing myiasis in man is probably absent.

**Literature.**—Keilin (*66*), Séguy (*134*).

### MUSCINA PABULORUM (Fallén)

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region; Scotland, England, Spain, France, Netherlands, Corsica, Norway, Sweden, Finland, Denmark, Germany, Poland, Czechoslovakia, Austria, Yugoslavia, Rumania, Russia, Canary Islands, Madeira, Egypt, Palestine, East China, Japan.

**Pathogenesis.**—This species is normally saprophagous or carnivorous; there is one record of it as a sheep maggot in Scotland.

## The Genus MUSCA Linnaeus

The genus *Musca* is used here in the sense employed by Patton and by Van Emden; so for the present purposes such generic names as *Byomya*, *Philaematomyia*, *Eumusca*, and *Viviparomusca* must be considered as synonyms. The genus is practically of world-wide distribution, although the species that dominates as a household pest will vary from one region to another.

Members of this genus are black to blackish flies, more or less covered with grayish pollen, and with the abdomen often extensively yellow or orange, sometimes wholly so. The pollen of the mesonotum may leave two or four black vittae, although in some species the mesonotum is wholly black. The arista is characteristically formed; the

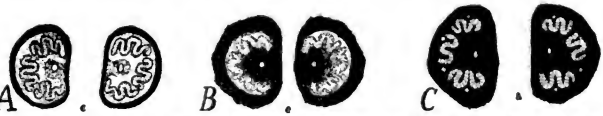


FIGURE 80.—Posterior spiracles of mature larva: *A*, *Musca domestica*; *B*, *M. sorbens*; *C*, *M. crassirostris*. (After Patton (*105*).)

terminal segment is strongly thickened basally and its plumosity is very long, the longest rays being usually half the length of the arista or longer. The peteropleura are hairy. Vein $m_{1+2}$ is strongly bent forward, is angular at its bend, and reaches the costa before the wing apex; vein $r_1$ is bare; the anal vein does not reach the wing margin.

**Life Histories.**—Within the genus the life histories vary considerably. Most species are oviparous, but in some the females deposit maggots which are in the second or even the third stage. Breeding grounds are varied and commonly include excrement of different types. Development is rapid, and there are several annual generations in temperate climates; in the Tropics breeding may be continuous. The adults of some species, notably *M. domestica*, *M. vicina*, and *M. sorbens*, are common household pests, but some species live habitually away from human habitations. Adults of other species are haematophagous, either making their own lesions by means of rasping labella or lapping blood from around wounds or punctures made by the true bloodsucking Diptera.

**Larva.**—The larva is a glossy whitish maggot of the common muscoid type. The posterior end is rounded and without noticeable tubercles; the posterior spiracles in the third-stage larvae are D-shaped, the straight side being inward and provided with three strongly sinuous slits (fig. 80).

**Literature.**—The works of Patton (*104*, *105*, *108*, *109*) will be found useful for the biology, immature stages, and taxonomy of the adults,

including keys to the Palaearctic, Ethiopian, and Oriental species. For a further treatment of the Ethiopian species, including a key, see Van Emden (*154, pp. 73–84*); for a key to the Australian species, see Hardy (*53*).

## KEY TO SPECIES

ADULTS

1. Mesonotum with 2 black vittae, which, in the females, are divided in the form of a Y in front of the suture ..... *sorbens* Wiedemann [12]
   Mesonotum with 4 complete black vittae ..... 2
2. Propleura distinctly pilose, although sometimes with but a few hairs; proboscis of the ordinary form, without a bulbous haustellum or prestomal teeth; palpi black ..... 3
   Propleura bare; proboscis thickened, with a bulbous haustellum and prestomal teeth (fig. 81); palpi yellow ..... *crassirostris* Stein
3. Front of male at narrowest point about 3 times as wide as the third antennal segment; abdomen largely infuscated in the female and with at least the third and fourth segments infuscated in the male. ..... *domestica* Linnaeus
   Front of male at narrowest point less than 3 times as wide as the third antennal segment; abdomen more or less bright orange, especially basally, and darkened on the fourth segment and at least the apex of the third in the male ..... *vicina* Macquart

THIRD-STAGE LARVAE

1. Posterior spiracles heavily sclerotized and without a peritreme (fig. 80, *C*) ..... *crassirostris* Stein
   Posterior spiracles with a distinct peritreme ..... 2
2. Peritreme thick (fig. 80, *B*) ..... *sorbens* Wiedemann
   Peritreme thin (fig. 80, *A*) ..... *domestica* Linnaeus
   *vicina* Macquart

## MUSCA CRASSIROSTRIS Stein

SYNONYMS.—*Philaematomyia crassirostris* (Stein); *Musca insignis* Austen.

RECOGNITION CHARACTERS.—Adult: This species is readily recognized by the light gray color, the olive or grayish-green abdomen, the yellow palpi, and the thickened bulblike haustellum (fig. 81). Thorax has four narrow vittae, the outer ones being interrupted at the suture. Length about 5–7 mm. Larva: The mature larva is of a characteristic lemon-yellow color; the anterior spiracles possess seven or eight fingerlike processes; the posterior spiracles are densely sclerotized, without a peritreme (fig. 80, *C*).

FIGURE 81.—*Musca crassirostris*, head of female, side view. (After Patton (*165*).)

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: China (Shantung), Libia, Egypt, Anglo-Egyptian Sudan (Khartoum), Dodecanese, Cyprus, Palestine, Arabia, Iraq, Iran. Ethiopian Region: Senegal, Gold Coast, Socotra, Belgian Congo, Rhodesia, South Africa (Transvaal). Oriental Region: India, Ceylon, Burma, Malaya, Taiwan, Philippine Islands, Sumatra, Borneo, Java.

**Biology and Pathogenesis.**—This species is oviparous; the eggs are deposited in masses in fresh cow or horse manure in the field. Development is rapid. The adult sucks blood; its proboscis is provided with a strong bulbous haustellum and with rasping prestomal teeth on the labella.

[12] *Musca sorbens* Wiedemann is the common housefly of extensive areas in the warmer parts of the Old World. It is not known to be involved in human myiasis.

Human parasitism is rare and of little consequence. Patton attributes the cases of intestinal myiasis known in India to the curious purification rite of eating the five products of the cow, including a small quantity of fresh dung, mixed together. Onorato (*96*) records a case of enteric myiasis from Tripolitania; as explanation of the infestation, he says that the indigent poor often search through horse dung for the undigested grains of barley which it contains, and that the patient, who admitted having done that, may have contaminated his own food with eggs or young larvae from his soiled hands.

## MUSCA DOMESTICA Linnaeus

## MUSCA VICINA Macquart

The Housefly; the Typhoid Fly

(Fig. 82)

The two species, or two varieties of one species, as they are variously considered by different authors, are treated together because for our purposes it is impracticable to separate them. Their records in the literature have been considerably mixed. The females are very difficult to separate, if they can be separated with certainty at all; the males of *M. vicina* have a much narrower front and a paler abdomen, although both these characters are subject to quantitative variation.

RECOGNITION CHARACTERS.—Adults: The adult is easily distinguished from other known species of *Musca* by the fact that the propleura are hairy (though sometimes with only a few hairs, and rarely bare), the thorax has four black vittae, and the abdomen, in addition to the median stripe, is infuscated on at least the third and fourth segments. The eyes are bare, the wing veins bare above and below, the front at least broader than the third antennal segment and with distinct frontalia, the proboscis of ordinary form, and the postsutural dorsocentrals all strong. Length 6–9 mm. Larva (fig. 83): Each anterior spiracle has five to seven fingerlike processes; each posterior spiracle has a well-developed peritreme of moderate width.

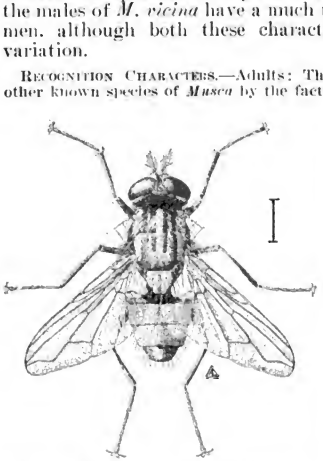

FIGURE 82.—*Musca domestica*, adult male.

GEOGRAPHICAL DISTRIBUTION.—Practically world-wide. *M. vicina* is apparently the form that occurs throughout the warmer parts of the Old World, including Africa, India, and the warmer parts of the Palaearctic Region; it also extends into the New World, at least in the West Indies. Since there is still considerable question as to whether it is distinct from *M. domestica*, the following records are for *M. vicina* and *M. domestica* combined: Nearctic Region.—Alaska, Labrador, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Florida, Mississippi, Ohio, Michigan, Indiana, Illinois, Kentucky, Minnesota, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Kansas, Louisiana, Oklahoma, Texas, Montana, Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona, Oregon,

California, Neotropical Region: Mexico, Baja California, Guatemala, Panama, Canal Zone, Bermuda, Bahama Islands, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Virgin Islands, St. Kitts, St. Vincent, Antigua, Martinique, Barbados, Grenada, Trinidad, Colombia, Galapagos Islands, Ecuador, Venezuela, British Guiana, Brazil, Ascension Island, Peru, Paraguay, Uruguay, Chile, Argentina, Patagonia. Palaearctic Region: Iceland, Ireland, Scotland, England, Spain, France, Netherlands, Switzerland, Italy, Corsica, Sardinia, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Poland, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, Greece, European Turkey, Russia, Transcaspia, Azores, Canary Islands, Madeira, Morocco, Algeria, Tunisia, Libia, Egypt, Dodecanese, Syria, Palestine, Iraq, Siberia (Tomsk), China (Shantung), Manchuria, Chosen, Japan. Oriental Region: India, Ceylon, Malaya, Taiwan, Philippine Islands, Sumatra, Borneo, Java. Ethiopian Region: Gold Coast, Nigeria, Sudan, Eritrea, Uganda, Kenya, Tanganyika, Zanzibar, Nyasaland, Mozambique, Rhodesia, South-West Africa, South Africa (Natal), Seychelles, Admirantes, Coetivy and Cargados Islands, Rodriquez. Australian Region: Western Australia, Northern Territory, South Australia, Queensland, New South Wales, Victoria, New Zealand, New Caledonia, New Hebrides (Espiritu Santo Island), Guam, Samoa, Fiji, Society Islands, Marquesas, Midway Islands, Hawaiian Islands.

**Biology and Pathogenesis.**—The housefly breeds in decaying and fermenting organic matter of sufficient moistness, and in human and animal excrement. It is oviparous. A single female may produce 120 to 150 eggs at a batch and may deposit from 5 or 6 to 20 or more

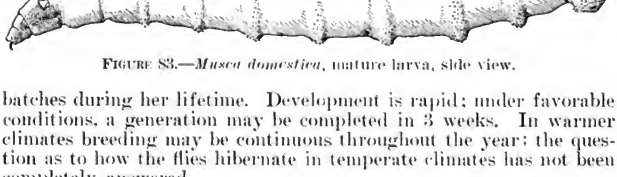

FIGURE 83.—*Musca domestica*, mature larva, side view.

batches during her lifetime. Development is rapid; under favorable conditions, a generation may be completed in 3 weeks. In warmer climates breeding may be continuous throughout the year; the question as to how the flies hibernate in temperate climates has not been completely answered.

In spite of the experiments of Komárek (*76*), it is hard to discredit statements by various workers that larvae of *M. domestica* have been recovered from stools and vomits under conditions that would preclude subsequent infection. Apparently authentic cases have been reported from Illinois, Scotland, South Africa, and other parts of the world. Seemingly authentic cases of urinary myiasis, similar to those produced by *Fannia*, have been reported. In a case reported by Leon (*81*) in Rumania, the actual emergence of the larvae from the urinary tract of a young man was observed. Some detailed observations on breeding habits are given by Mellor (*88*).

Several cases of wound and cuticular myiasis in man and animals are on record; in most of these, however, the larvae attack only the diseased tissue. In India larvae have been known to attack the diseased nasal cavities and wounds on the bodies of lepers. A severe auricular myiasis in the suppurating ear of a boy and an extensive dermal myiasis in the leg of an elderly man with varicose veins have also been reported. In the man the larvae probably hatched from eggs deposited on or near an ulcerous cavity; though some had reached the third stage, they were undersized and gave evidence of attempting

to escape from the unsuitable breeding medium. Cases of ocular myiasis are known.

**Literature.**—The literature on the housefly is voluminous. A good general work, which is more recent than Hewitt's well-known book, is Austen (*6*) and its somewhat abbreviated revision, Austen (*7*).

## The Family TIPULIDAE

The Crane Flies

Members of this family are slender, very long-legged flies, with a many-segmented antenna and a rather primitive wing venation. An outstanding feature is the prominent V-shaped suture, the apex pointing backward, on the mesonotum, in place of the usual transverse suture. In the typical tipulids ocelli are lacking, and there are two anal veins that reach the posterior margin of the wing. Most members of the family are of medium to rather large size.

Cases of intestinal myiasis supposedly due to larvae of unidentified members of this family have been recorded.

## The Family PSYCHODIDAE

The Moth Flies

These are small flies, rarely exceeding 4 mm. in length. The wings are broad, often pointed, and are clothed with hairs or scales; when at rest they are usually folded rooflike over the back. The costa is continued around the margin of the wing; cross veins, when present, are limited to about the basal third of the wing; two or three of the longitudinal veins are forked. Ocelli are absent.

**Larva.**—The larvae are chiefly aquatic or semiaquatic, although there are exceptions, notably *Phlebotomus*. They are elongated and cylindrical or somewhat flattened dorsoventrally; the head is distinct; the body segments are each divided secondarily into annuli, usually two for each thoracic and the first abdominal, and three for abdominal segments 2 to 7; certain of the annuli may possess sclerotized dorsal transverse bands. Respiration is through a pair of anterior spiracles and a single posterior respiratory tube.

### The Genus PSYCHODA Latreille

The wing (fig. 84, *A*) is ovate-lanceolate, the veins and sometimes the membrane clothed with hairs but not with scales; there are two unforked veins ($r_4$ and $r_5$) between the anterior forked vein ($r_{2+3}$) and the posterior one ($m_{1+2}$), and 3 unforked veins ($m_3$, $cu_1$, and $cu_2$+ 2nd *A*) behind the latter; vein $r_5$ ends in the pointed wing apex. The antennae are 14 to 16 segmented, the first 13 being subglobose, the remaining 1 to 3 segments small.

**Larva.**—The larva (fig. 85) is more or less cylindrical and, when mature, is several times as long as the adult; the body is grayish white, and the integument is covered with pale flattened hairs or scales, some of which have dentate margins. The antennae are very short; the respiratory tube slender, the lobes at its tips small.

**Taxonomy.**—The taxonomy is difficult. The important characters found in the wing venation, antennae, and male genitalia cannot well

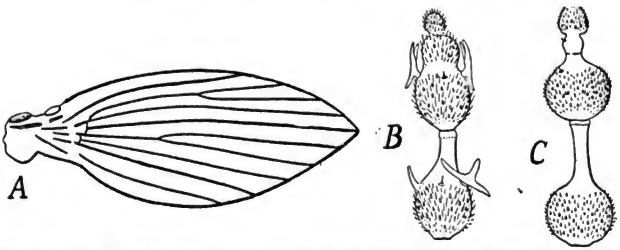


FIGURE 84.—*A*, *Psychoda alternata*, denuded wing, to show venation; *B*, *P. alternata*, terminal antennal segments; *C*, *P. albipennis*, terminal antennal segments. (After Tonnoir (*150*).)

FIGURE 85.—*Psychoda alternata*, larva. (After Johannsen (*61, pl. 12, no. 99*).)

be studied from specimens mounted in the ordinary way; for positive identifications cleared specimens mounted on microscope slides may be necessary.

Johannsen (*61, p. 23*) gives a key to larvae. For adults see Del Rosario (*125*) for the American species and Tonnoir (*150*, *151*) for the European species.

### PSYCHODA ALBIPENNIS Zetterstedt

RECOGNITION CHARACTERS.—Adult: This is a medium-sized species, about 1.25 mm. in length. The antenna (fig 84, *C*) is 15-segmented; the thirteenth segment is subglobular; the last two are rather closely conjoined, not globular, and very small, their combined length being less than that of the thirteenth; the fourteenth segment lacks pubescence. The wings are unmarked; the two main forks are complete at the base.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Scotland, England, France, Netherlands, Belgium, Norway, Sweden, Austria. Ethiopian Region: Seychelles.

**Biology and Pathogenesis.**—The larvae are found in moist places, such as ditches, decaying moist vegetable matter, decaying fruit, the sides of drains, and in filter beds of sewage-disposal plants, where they may occur very abundantly on the bacterial film.

Patton and Evans (*111, p. 487*) have reported a case of urinary myiasis in a boy in Scotland. Larvae were passed with the urine and others were extracted from the bladder with a cystoscope; the bladder appeared inflamed. As the boy admitted having eaten moist earth, the authors concluded that the larvae were ingested in this way and had burrowed from the rectum into the bladder; it is more probable, however, that infestation occurred directly through the urinary passages.

### PSYCHODA ALTERNATA Say

SYNONYM.—*Psychoda sexpunctata* Curtis.

RECOGNITION CHARACTERS.—Adult: This is a moderately large species, about 1.5 mm. in length; the wing (fig. 84, *A*) has a mottled appearance, with black spots formed of tufts of black hairs at the apices of certain wing veins; three or four

such spots occur before the wing apex (at the ends of veins $r_1$, $r_2$, $r_4$, and sometimes $r_3$) and three behind (at the ends of veins $m_1$, $m_3$ and $cu_2$+2nd $a$). The antenna (fig. 84, *B*) is 15-segmented, the thirteenth and fourteenth segments being closely united to each other, and the fifteenth being smaller than either of the two preceding; the tip of the labium is not enlarged and is not provided with teeth. Larva, (fig. 85): Larval characters are discussed by Johannsen (*61*, p. 27) and Malloch (*85*, p. 267) but at present they are too poorly known for any to be considered as diagnostic.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Quebec, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Florida, Tennessee, Ohio, Michigan, Illinois, Minnesota, Missouri, South Dakota, Kansas, Texas, Montana, New Mexico, Washington, Oregon, California. Neotropical Region: Puerto Rico, St. Vincent, Venezuela, British Guiana, Chile. Palaearctic Region: England, France, Belgium, Italy, Malta, Norway, Sweden, Finland, Denmark, Germany, Czechoslovakia, Austria, Hungary, Canary Islands, Madeira, North Africa, Japan (?). Oriental Region: India, Philippine Islands. Ethiopian Region: Gold Coast, Nigeria, Belgian Congo, South Africa, Seychelles. Australian Region: New South Wales, New Guinea, Hawaiian Islands.

**Biology and Pathogenesis.**—The larvae may be found on the surface film of foul water, in sewage, in the filter beds of sewage-disposal plants, and in various types of wet, decaying organic matter; they are frequently found in the traps of washbowls, and are capable of developing in water pipes.

Eggs are laid in irregularly shaped masses of 20 to 100 or more. The larvae hatch within 2 days; their development is rapid.

One case has been recorded of a girl in Japan vomiting living larvae of "*Psychoda b. punctata*"; this was probably intended for *6-punctata* (*sexpunctata*), which is a synonym of this species.

## The Family SYLVICOLIDAE

This family has been variously known as the Rhyphidae, Phryneidae, and Anisopodidae (Anisopidae). The antennae are 12- to 16-segmented, segments beyond the second not fused into a flagellum;

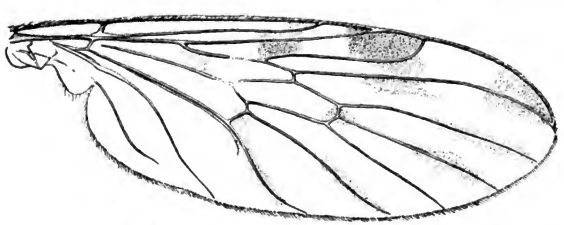

FIGURE 86.—*Sylvicola fenestralis*, wing.

ocelli are present. Though related to the crane flies, the V-shaped mesonotal suture that characterizes that group is absent in this family. The wing venation is of a primitive type (fig. 86); in the more representative members of the family the discal cell is present and the media is 3-branched.

The family has been treated in the "Genera Insectorum" by Edwards (*38*) and in Lindner's "Die Fliegen der Palaearktischen Region."

## The Genus SYLVICOLA Harris

Commonly used synonyms are *Rhyphus*, *Phryne*, and *Anisopus*. This genus may readily be distinguished from the others which have a complete discal cell and a three-branched media by the numerous

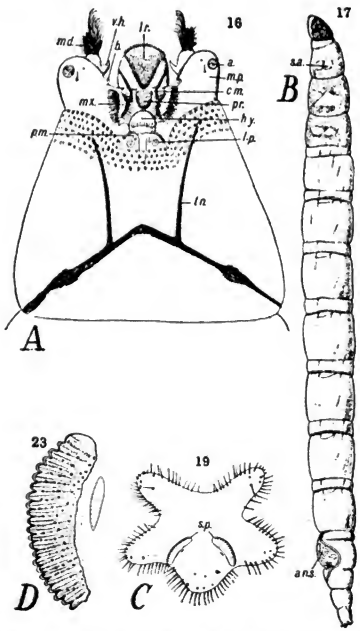


FIGURE 87.—*Sylvicola fenestralis*, larva: *A*, Head, ventral view; *B*, mature larva, side view; *C*, view of last body segment; *D*, posterior spiracle. (After Keilin and Tate (*68, p. 46*).)

macrotrichia or hairs on the wing membrane; the macrotrichia, though microscopic, are as large as the hairs on the veins, and are not to be confused with the smaller microtrichia normally present on the dipterous wing. In addition, the hind tibia bears a comb of short spinules on its posterodorsal surface.

**Larva.**—The larva (fig. 87) has a free and complete head capsule, three simple thoracic segments, and eight abdominal segments which are divided transversely to form anterior intercalary rings. The anterior spiracles are distinct; the posterior spiracles are crescent-shaped, and the spiracular area is surrounded by five short but distinct processes; the anus is ventral and is surrounded by a shieldlike thickening called the perianal shield.

**Literature.**—For biology and immature stages see Edwards (*38*), and Keilin and Tate (*68, pp. 44–51*); for keys to the species of the world, see Edwards (*38*).

#### SYLVICOLA FENESTRALIS (Scopoli)

SYNONYMS.—*Phryne fenestralis* (Scopoli). *Anisopus fenestralis* (Scopoli), *Rhyphus fenestralis* (Scopoli).

RECOGNITION CHARACTERS.—Adult: The palpi are blackish; the eyes are well separated in both sexes. The wing (fig. 86) is distinctly mottled; its apex is dark, the stigma well marked, and the spot between the stigma and the apical region hyaline, not conspicuously whitish; the first basal cell has a dark spot below the origin of the radial sector, but is clear below the fork of that vein. The hind femur is darkened at its middle, the darkening, however, being often obscure. Length 5–7 mm. Larva: The mature larva (fig. 87) is 12–15 mm. in length; the integument is yellowish though because of its transparency the internal organs show through and give the body a pinkish cast. Each thoracic segment has characteristic patches of a deep brown color; these are lacking on the abdomen. The last segment is subdivided into several annuli; the perianal shield is confined to the ventral half of the segment.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Nova Scotia, Quebec, Ontario, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Minnesota, Wisconsin, Idaho, Washington, California. Palearctic Region: Ireland, Scotland, England, Portugal, France, Netherlands, Italy, Norway, Sweden, Finland, Czechoslovakia, Austria, Hungary, Azores.

**Biology and Pathogenesis.**—Larvae have been found in various situations involving fermenting organic matter, such as cow dung, fermenting potatoes, decaying roots, fermenting sap in tree holes, and home-made cider and wine. One remarkable case has been reported of larvae breeding in liver that had been preserved in 10-percent formalin for 10 years and at the time of infestation was partly submerged in the formalin. The larvae move in a serpentine manner. Pupation takes place in the medium in which they live.

A case of enteritis in a child in England is recorded in which larvae of this species were recovered at intervals over a period of 3 weeks.

## The Family STRATIOMYIDAE

The Soldier Flies

This family is readily recognized by the peculiar wing venation, which is of the general type found in the Therevidae (fig. 3), but with the major veins crowded toward the costal margin (fig. 88). The adults are variable in size and form. Many are brightly colored or marked with bright patterns, but some are dark or drab.

**Larva.**—The larvae, like the adults, are variable, but in general they are strongly flattened, with the body finely shagreened; the head is well developed; the mandibles move vertically and when at rest assume a vertical position; the posterior spiracles are closely approximated and situated within a terminal or subterminal cleft or chamber, where they are usually concealed. Many larvae are aquatic; the terrestrial larvae are mostly scavengers, though some are predaceous.

### The Genus HERMETIA Latreille

Members of this genus are rather easily recognized; they are of medium to moderately large size; the antennae are elongated, the last segment being flattened and vanelike, and the segments (or annuli) immediately preceding have a flattened or depressed longitudinal

area on the inner side. Cross vein *m-cu* is lacking; the scutellum is unspined.

**Larvae.**—The larva (fig. 89) is robust, broad-ovate, not distinctly tapering; the head is slender, with moderately well-developed antennae and eyes; the surface is clothed with numerous short hairs and with bristles arranged almost in transverse rows.

### HERMETIA ILLUCENS (Linnaeus)

(Fig. 88)

Recognition Characters.—Adult: This is a moderately large, black species, with two translucent spots on the second abdominal segment; the apex of the abdomen is sometimes reddish; the eyes are bare, the tarsi whitish to pale

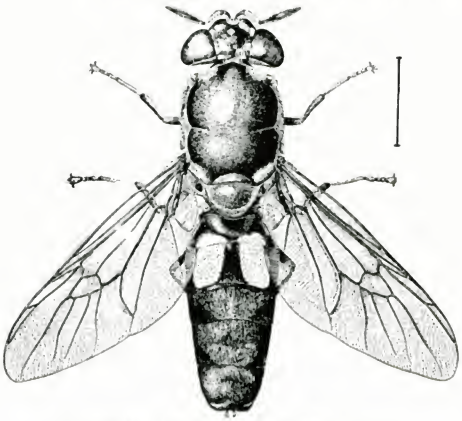

Figure 88.—*Hermetia illucens*, adult female.

yellowish, the wings uniformly dusky, and the fringes of the squamae dusky. Length 15-20 mm.

Geographical Distribution.—Nearctic Region: New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Missouri, Arkansas, Louisiana,

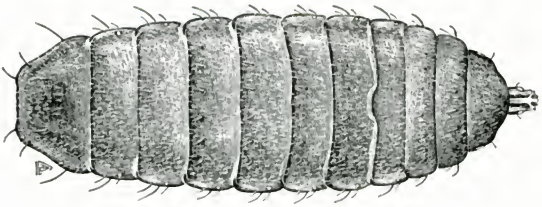

Figure 89.—*Hermetia illucens*, larva.

Oklahoma, Texas, Arizona, California. Neotropical Region: Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Canal Zone, Bahama Islands, Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Guadeloupe, Martinique, Barbados, Trinidad, Colombia, Ecuador, Venezuela, British Guiana, French Guiana, Brazil, Peru, Bolivia, Paraguay, Uruguay, Argentina. Palaearctic Region: Malta. Australian Region: Samoa, Guadalcanal, Bougainville, Hawaiian Islands.

**Biology and Pathogenesis.**—The larvae breed in various substances, such as decaying fruits and vegetables, catsup, animal cadavers, and the wax, honey, pollen, and waste materials found in beehives. They are remarkably hardy. In the southern part of the United States they are common in outdoor privies.

Several cases of intestinal myiasis in man, apparently authentic, have been reported, the large and vigorous larvae causing rather severe gastrointestinal disturbances.

## The Family THEREVIDAE

The Stiletto Flies; the Snipe Flies

The Therevidae form a family of predaceous flies of medium size. Some of them resemble certain Asilidae, but they may readily be distinguished by the fact that the vertex is not excavated, as it is in that family; others are bombyliidlike, but, unlike the members of that family, have five posterior cells (fig. 3). The larvae, like the adults, are predaceous. They live in fungi, rotten tree trunks, and soil; some are said to parasitize Lepidoptera.

The Palaearctic species have been treated in Lindner's "Die Fliegen der Palaearktischen Region."

### The Genus THEREVA Latreille

This is a genus of typically furry or hairy species; the parafacials are pilose; the first antennal segment is slender and much shorter than the length of the head. Cell $r_1$ takes in the wing apex; cell $r_5$ is not divided by an extra cross vein beyond the furcation of vein $r_{4+5}$.

#### THEREVA NOBILITATA Fabricius

This is a variable species in a difficult genus, and to attempt to give distinguishing characters in a limited space would serve no useful purpose.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Scotland, England, Spain, France, Netherlands, Switzerland, Italy, Capri, Corsica, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Czechoslovakia, Austria, Hungary, Yugoslavia, European Russia, Turkestan.

**Pathogenesis.**—Austen (*5*) records a case in England of a larva of a species of *Thereva*, probably *nobilitata*, being "coughed up by a man who had 'complained of a bad throat' for about a week," and cites a previous case in Germany where a 2-weeks' illness ceased after the patient had vomited a living larva of *T. nobilitata*.

## The Family SYRPHIDAE

The Hover Flies and Drone Flies

Members of this family are typically medium-sized flies of dark color, with bright tegumentary spots or bands on the body; many, however, vary from this general color scheme. A character which

is present in most members of the family and which is rarely found elsewhere is the spurious vein, a veinlike fold in the membrane between veins $r_{4+5}$ and $m_{1+2}$, and transversing the cross vein *r-m*. The venation is reduced from the type found in such families as the Sylvicolidae, Stratiomyidae, Asilidae, and Therevidae, but not so much as in the muscoids; the anal cell is always long but is closed before the wing margin.

**Larva.**—The habits of the larvae vary. Many are carnivorous, feeding particularly on aphids but also on other Homoptera; some are plant feeders; many species are scavengers. Some of the scavengers have symbiotic relations with termites and social Hymenoptera, whereas others occasionally become accidental parasites of man and animals.

**Literature.**—Useful summaries of the role of Syrphidae in myiasis of man and domestic animals have been published by Hall and Muir (*51*), Hall (*50*), and by Metcalf (*89, pp. 207, 217–219*).

The generic descriptions included in this work will, in general, distinguish the genera discussed here from others in the Holarctic Region. For keys to the adults consult Curran's "North American Diptera" and Lindner's "Die Fliegen der Palaearktischen Region;" for larvae see Johannsen (*62, pp. 22–24*). A valuable and more recent work by Heiss is not cited, because it does not include the rat-tailed species.

## The Genus SYRPHUS Fabricius

This genus contains a number of species of familiar flies, the hover flies, which are, for the most part, black or blackish, with prominent yellow spots or bands on the abdomen. The larvae are carnivorous, by far the greater part of their prey consisting of aphids.

Austen (*5*) records three instances of supposed myiasis caused by larvae of this or of the related genus *Scaeva* (as *Lasioptieus*). In two cases larvae were submitted by medical men as having been discharged by patients through the rectum; in the third case a larva was removed from the ear of a boy who had been troubled by pain and deafness in that ear for 2 days.

The occurrence of a larva within the ear was probably accidental, and can hardly be regarded as myiasis; the other records cannot be accepted without substantiation. Any habits related to myiasis are entirely foreign to members of this genus. Without doubt, larvae may be ingested with brussels sprouts and other vegetables which in the growing stage harbor colonies of aphids, but it is highly doubtful whether they could cause enteric disturbances or pass through the digestive tract alive.

## The Genus TUBIFERA Meigen

This genus has commonly been known as *Eristalis*, and some workers have applied the name *Eristalomyia* to *tenax* and related species.

The adults are beelike in appearance, those of *T. tenax* resembling the drone honeybee. The eyes are pilose; the face is tuberculate in the middle; the epistoma is not produced; the antennae are short, the third segment rounded or oval, with a dorsal arista. The thorax is

more or less hairy, but never with hair that is squamose; the humeri are pilose. Vein $r_{4+5}$ curves strongly into the middle of the apical cell; the marginal cell is closed and petiolated.

**Larvae.**—The larva (fig. 90) is the familiar rat-tailed maggot; but all rat-tailed larvae do not, by any means, belong to this genus. The assumption that all such larvae are *T. tenax* is undoubtedly responsible for many incorrect records and inaccurate descriptions.

The "rat-tail," or respiratory tube, consists of 3 segments; when contracted, the second and third are telescoped into the first, so that the second is entirely concealed and only the tip of the third shows. When fully distended, in the mature larva, the respiratory tube is

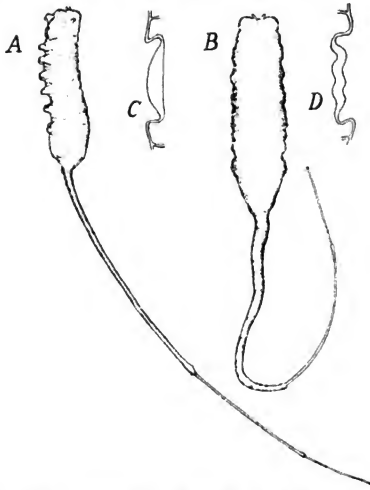


FIGURE 90.—*A*, Larva of *Tubifera*, side view; *B*, same, dorsal view; *C*, same, tracheal trunk; *D*, larva of *Helophilus*, tracheal trunk. (After Johannsen, *61, pl. IV*).)

at least twice, and usually several times, the length of the body. The body is more or less cylindrical and is pilose; the abdominal segments lack the lateral lobes found in some genera of Tubiferinae; the tracheal trunks (fig. 90, *C*) are straight; the anal gills, 9 to 20 in number.

**Pathogenesis.**—A number of seemingly authentic cases of gastrointestinal myiasis have been recorded. An unidentified species of *Tubifera* has been removed from the nose of a patient, and vaginal myiasis has been reported in cattle.

**Literature.**—The Palaearctic species have been treated in Lindner's "Die Fliegen der Palaearktischen Region." For a key to the New World species, see Curran (*28, p. 3–7*), and for a discussion of the immature stages, Johannsen (*62, pp. 25–26*).

## KEY TO SPECIES

ADULTS

1. Eye on the middle third with a definite band of pile which is distinctly denser than that of the anterior or posterior third; third abdominal segment wholly shining; arista with pubescence which is not longer than its diameter; honeybeelike species_____ *tenax* (Linnaeus)
   Eye without a zone of denser pile in the median third; third abdominal segment with opaque, black areas; arista with some hairs which are longer than its diameter; beelike, but not honeybeelike, species_____ 2
2. Face with a polished area on and around the tubercle and usually with a brownish or blackish vitta; aristal pubescence but little longer than its diameter; third abdominal segment with a small round opaque spot in addition to the preapical band_____ *dimidiata* (Wiedemann)
   Face entirely pollinose, aristal pubescence several times its diameter; third abdominal segment with a prebasal as well as a preapical opaque band_____ *arbustorum* (Linnaeus)

### TUBIFERA TENAX (Linnaeus)

The Drone Fly

(Fig. 91)

SYNONYMS.—*Eristalis tenax* (Linnaeus), *Eristalomyia tenax* (Linnaeus).

RECOGNITION CHARACTERS.—Adult: This species is similar to the drone honeybee in its general appearance. The antennae are brownish black; the arista is not plumose, but has distinct short pubescence on its basal part. The pilosity of the eyes is arranged in the form of three vertical bands, the middle one being much denser than the anterior and posterior ones. The thorax is uniformly dark but clothed with some yellowish hair; the abdomen is shining, black and reddish yellow, the amount of the reddish yellow varying and sometimes predominating. Length about 15 mm. Larva: Some characters of the larva are discussed by Johannsen (*62, pp. 27–28*), but it would be unsafe to indicate any as diagnostic.

GEOGRAPHICAL DISTRIBUTION.—The general distribution seems to be almost world-wide, yet lacking or rare in many tropical areas. Nearctic Region: New Brunswick, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Ohio, Michigan, Indiana, Illinois, Minnesota, Wisconsin, Missouri, Nebraska, Kansas, Louisiana, Montana, Idaho, Colorado, Utah, New Mexico, Washington, Oregon, California. Neotropical Region: Mexico, Bermuda, Peru, Uruguay, Chile, Argentina, Patagonia. Palaearctic Region: Ireland, Scotland, England, Spain, Gibraltar, France, Netherlands, Italy, Corsica, Sardinia, Sicily, Malta, Norway, Sweden, Lapland (Swedish), Denmark, Germany, Czechoslovakia, Austria, Hungary, Rumania, Greece, European Russia, Azores, Cape Verde Islands, Canary Islands, Madeira, Morocco, Algeria, Tunisia, Libia, Syria, Iran, Siberia, Lake Baikal Region, China, Manchuria, Chosen, Japan. Oriental Region: India, Ceylon, Burma, Federated Malay States, Taiwan. Ethiopian Region: South Africa (Transvaal, Cape of Good Hope), Madagascar, Reunion Islands. Australian Region: New South Wales, Victoria, New Zealand, Hawaiian Islands.

**Biology and Pathogenesis.**—The larvae live in water contaminated by sewage, liquid excrement, decaying carcasses, and other foul organic matter; occasionally they may be found in relatively clean water. They may also breed in manure of a soft or liquid consistency, or in decaying plant and animal matter.

The larva is extremely resistant to adverse conditions. Numerous authors, including Linnaeus, have noted the ability of the larvae to withstand crushing pressure. Austen (*5*) cites an instance in which they went through dyeing vats alive, and another in which they lived in rock pools containing rotting seaweed, where they were exposed to changing salinity and to the hot sun each day.

A number of cases of gastrointestinal myiasis caused by this species have been reported. Some may have been due to subsequent contami-

nation of the feces, since it has been demonstrated that larvae may, on occasion, seek out fresh excrement; however, others seem to be authentic. Some records may be misidentification of other species of *Tubifera* or related genera; nevertheless, some have been derived from reared specimens. Two cases of occurrence within the vagina of a cow are on record.

Important references relating to the pathogenesis of this and related

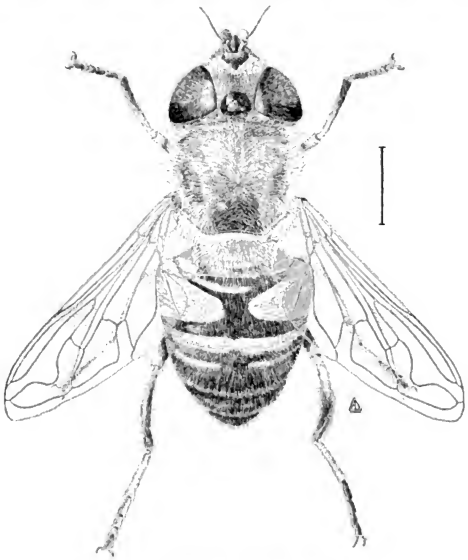

FIGURE 91.—*Tubifera tenax*, adult female.

species are Hall and Muir (*51*), Hall (*50*), and Bacigalupo and coworkers (*9*).

### TUBIFERA DIMIDIATA (Wiedemann)

SYNONYM.—*Eristalis dimidiatus* Wiedemann.

RECOGNITION CHARACTERS.—Adult: This is a beelike fly with a uniformly black thorax and predominantly black abdomen, which does, however, have narrow yellow apices to the segments and a pair of yellow side spots on segment 2 and sometimes also on segment 3. The arista has a few hairs on its basal third that are longer than its diameter; the face is shining on and around the prominence, and usually with a brownish or blackish median stripe. The postalar callus is provided with a number of blackish hairs. The abdomen is mainly shining; the third segment has a round basal spot and an interrupted subapical band of opaque black; similar opaque areas on the second segment are more extensive, but on the fourth segment only the basal round spot is present. Length, about 12 mm. Larva: No satisfactory distinguishing characters can be given at present.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Nova Scotia, Ontario, Quebec, Alberta, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Con-

necticut, New York, New Jersey, Maryland, District of Columbia, Virginia, North Carolina, Florida, Ohio, Michigan, Indiana, Illinois, Minnesota, Wisconsin, Missouri, Nebraska, Kansas, Idaho, Utah.

**Biology and Pathogenesis.**—This species has been reported by Riley (*120*) as involved in gastrointestinal myiasis (not auricular, as stated by Metcalf).

### TUBIFERA ARBUSTORUM (Linnaeus)

SYNONYM.—*Eristalis arbustorum* (Linnaeus).

RECOGNITION CHARACTERS.—Adult: This is a blackish fly, with short hair; the mesonotum is uniformly colored; the abdomen has the apices of the second to fourth segments narrowly yellow, with prominent yellow spots on the sides of the second and sometimes the third segment. The face is entirely whitish pollinose; the pubescence near the base of the arista is several times as long as the greatest diameter of the arista; the middle tarsi are reddish at the base; and the third abdominal segment has a broad subbasal as well as a broad subapical opaque band. Length about 11 mm. Larva: No satisfactory distinguishing characters can be given at present.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: Labrador, Nova Scotia, New Brunswick, Quebec, Ontario, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Ohio, Michigan, Indiana, Wisconsin, Missouri, Wyoming, Utah, Washington. Neotropical Region: Jamaica. Palaearctic Region: Faeroes, Ireland, Scotland, England, Spain, France, Netherlands, Switzerland, Italy, Corsica, Sardinia, Sicily, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Czechoslovakia, Austria, Hungary, Rumania, Greece, Azores, Morocco, North Africa, Syria, Iran, Siberia (Tobolsk), Manchuria. Oriental Region: India (Kashmir).

**Biology and Pathogenesis.**—Adults have been reared from larvae said to be passed with the feces by a patient in Germany.

## The Genus HELOPHILUS Meigen

Considerable confusion has arisen in regard to the true name for this genus. Some writers have used *Tubifera*, but that name is properly applied to quite another genus.

The adults are medium-sized, blackish but brightly marked flies, with prominent longitudinal vittae of yellowish pollen on the thorax and prominent yellow tegumentary side spots and bands on the abdomen. The eyes are bare; the antennae are much shorter than the face, with an oval third segment and a dorsal arista; the face is marked with a median shining stripe. The hind femora are thickened, but without a tooth or tubercle. The thoracic squamae are hairy above; the marginal cell is open; vein $r_{4+5}$ curves strongly into the middle of the apical cell.

**Larvae.**—The larvae are similar to those of *Tubifera*. However, the tracheal tubes, which are straight in *Tubifera*, are undulating in this genus (fig. 90, *D*); the integument is sufficiently transparent that these structures can be seen without dissection.

### HELOPHILUS PENDULUS (Linnaeus)

RECOGNITION CHARACTERS.—Adult: The antennae and the polished facial stripe are black. The pollinose stripes of the mesonotum are yellowish and reach the scutellum. The femora are black with broad yellow apices. The second and third abdominal segments each bear a pair of prominent yellow tegumentary spots, which do not reach the posterior margins of the segments except narrowly; the fourth segment bears an interrupted pollinose cross band; the narrow posterior margins of the second and third, and fourth segments are yellow in ground

color. Length about 11–13 mm. Larva: No satisfactory distinguishing characters can be given.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: This species was recorded from Alaska, but the record was due to misidentification. Palaearctic Region: Iceland, Faeroes, Ireland, Scotland, Wales, England, Spain, France, Netherlands, Switzerland, Italy, Sicily, Norway, Sweden, Finland, Lapland (Swedish), Denmark, Germany, Czechoslovakia, Austria, European Russia (northward to Arkhangelsk), Madeira.

**Pathogenesis.**—This species has been accused of producing intestinal myiasis, although the determination was made from the larva alone and is quite probably erroneous. Chevrel (*27, p. 377*) cites a supposed case of urinary myiasis, which he considers probably due to the subsequent entrance of the larva into the vessel containing the urine.

## The Family EPHYDRIDAE

These are the shore flies which are often abundant in moist places. Only one genus has been reported as involved in myiasis.

### The Genus TEICHOMYZA Macquart

The name of this genus has been emended to *Tichomyza*, but it is better to follow the original spelling.

The genus is known to occur definitely only in Europe and western South America. It may be distinguished from the other European genera of Ephydridae by the following combination of characters: The eyes are bare. The second antennal segment has only the ordinary hairs above, without the crooked apical spine characteristic of many members of this family; the arista is bare. The oral opening is large; the face is prominent and convex, clothed with scattered hairs, and with a row of strong downwardly directed bristles along the oral margin and a row of bristles on each side of the facial prominence. The clypeus is small, usually not extending below the oral margin. There are two pairs of dorsocentral bristles, which are postsutural, and one of acrosticals, which are presutural; there are 3 pairs of laterosecutellars. The wings are uniformly infuscated; the costa reaches vein $m_{1+2}$. Only one species has been described.

#### TEICHOMYZA FUSCA Macquart

RECOGNITION CHARACTERS.—Adult: This is a brownish-black species, about 4 mm. in length. Larva (fig. 92): The mature larva is 10–13 mm. in length, cylindrico-fusiform, translucent, and covered with small blackish setulae. Each of the thoracic segments beyond the first and abdominal segments anterior to the seventh bears an ambulatory protuberance (proleg) on each side, near the middle; each anterior spiracle ends in about 18 digitate processes; the posterior spiracles are on long stalks projecting backward; the mouth hooks are toothed below.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: All Europe (according to Becker), Ireland, England, France, Netherlands, Italy, Germany, Czechoslovakia, Bulgaria, European Russia. Neotropical Region: Chile; also on shipboard off the coast of Peru.

**Biology and Pathogenesis.**—The larvae are frequently found in outdoor urinals and excrement; they breed in wet places, but not in deep urine or water. Numerous cases of urinary myiasis have been recorded. Chevrel (*27*) discusses three of these in detail, and though evidence points toward their authenticity, he leaves them in a questionable status, as did the physician who reported them. Since details of

two cases of intestinal myiasis, both in females, are lacking, these may not be authentic, or they may actually have been cases of urinary myiasis.

**Literature.**—For a detailed and apparently careful, though old, description of the immature stages, see Laboulbène (*78*); for a more re-

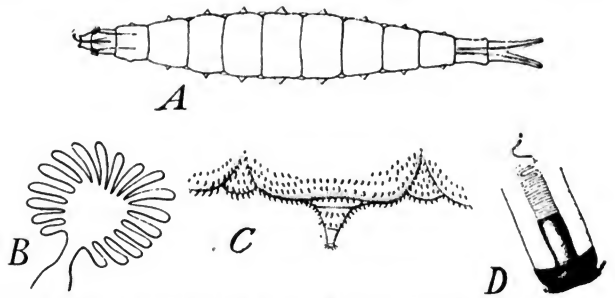


FIGURE 92.—*Teichomyza fusca*, larva: *A*, Dorsal view; *B*, enlargement of anterior spiracle; *C*, enlargement of abdominal ambulatory protuberance; *D*, enlargement of posterior spiracle. (After Laboulbène (*78, pl. 5*).)

cent one, see Vogler (*156*); for pathogenesis, see Laboulbène (*78*) and Chevrel (*27, p. 384*); for the taxonomy, see Becker (*12*).

## The Family DROSOPHILIDAE

This is a family of small flies, rarely exceeding 5 mm. in length. In its typical members the arista is plumose, the postvertical bristles are convergent, the vibrissae are present, the costa is twice broken, vein *sc* is rudimentary, and the anal cell is complete; all these characters, however, are subject to variation in some genera. The family includes the small, yellowish flies so well known in genetical research. Only one genus has been reported as involved in human myiasis, and such reports as we have are not convincing as to the actual pathogenic role in this respect.

For a guide to the taxonomy of the American species, as well as for considerable information on the biology and immature stages, see Sturtevant (*147*) and Patterson (*98*).

### The Genus DROSOPHILA Fallén

Species of *Drosophila* have all the characters given above as typical. In addition the head and pronotum are of the usual form, the head being no broader than the thorax and the pronotum being shorter than the head; the lower reclinate fronto-orbital bristle is behind the proclinate fronto-orbital, yet much closer to that bristle than to the upper reclinate fronto-orbital; there are two dorsocentrals and no acrostical bristles; the acrostical hairs are short and appressed and arranged in six or more rows; the discal and second basal cells are united.

**Larvae.**—The larva is a small white maggot of the muscoid type with prominent tubercles on the last abdominal segment and with stalked posterior spiracles, the stalks of which are contiguous at their bases (fig. 93).

### DROSOPHILA MELANOGASTER Meigen

The Pomace Fly

SYNONYM.—*Drosophila ampelophila* Loew.

RECOGNITION CHARACTERS.—Adult: The facial carina is prominent; the cheeks are narrow, their greatest width being about one-fifth the greatest diameter of the eyes. The mesonotum is yellow and unmarked; the pleura likewise yellow, without a dark stripe or spots. The acrostical hairs are in 8 rows. The male has a comb of short stout bristles on the anterior basitarsus. The abdomen is black, with a broad yellowish band on each of the first three segments; these bands may be obscure in the female. Length about 2 mm. Larva (fig. 93, *A*): This is a rather robust larva, about 5–6 mm. in length. The last 10 segments bear fusiform areas of spines ventrally, although the first and sometimes also the second segments are not easily seen. The posterior spiracles are light yellow; the posterior end of the body before the spiracles is truncated and rather hairy.

GEOGRAPHICAL DISTRIBUTION.—Widespread through the warmer and temperate parts of the world. Nearctic Region: Nova Scotia, Quebec, Ontario, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Ohio, Indiana, Illinois, Minnesota, Wisconsin, Missouri, South Dakota, Kansas, Arkansas, Louisiana, Oklahoma, Texas, Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico, British Honduras, Costa Rica, Panama, Canal Zone, Bermuda, Bahama Islands, Cuba, Jamaica, Dominican Republic, Puerto Rico, Barbados, Ecuador, Brazil, Peru, Bolivia, Uruguay, Chile, Argentina. Palaearctic Region: Ireland, England, Spain, France, Netherlands, Italy, Sicily, Sweden, Finland, Germany, Austria, Hungary, European Turkey, European Russia (northward to Arkhangelsk), Azores, Algeria, Libia, Egypt, Japan. Oriental Region: Malaya, Taiwan, Philippine Islands. Ethiopian Region: Mozambique, South Africa. Australian Region: South Australia, New South Wales, New Zealand, Samoa, Fiji, Marquesas, Hawaiian Islands.

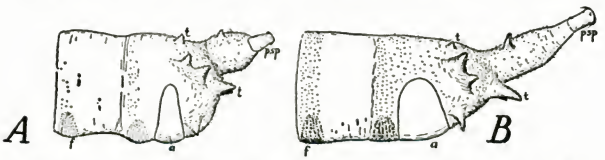


FIGURE 93.—*A*, *Drosophila melanogaster*, terminal abdominal segments of larva; *B*, *D. funebris*, same. (After Keifer (*64*, *p. 576*).)

**Biology and Pathogenesis.**—This is the fly so well known to geneticists. The larvae breed in a wide variety of overripe fruits, as well as stale beer, and, very exceptionally, human excrement. Females have been known to oviposit when a day old, but oviposition and mating usually take place the second or third day. Development is very rapid, usually being completed under laboratory conditions in 8 to 12 days. It is doubtful whether it can hibernate in the cooler parts of its range, but the supply is easily restocked from shipped-in fruits.

This species has been reported to produce intestinal myiasis, but such a possibility seems highly questionable. Inasmuch as this species occurs in fruits which are still fit for human consumption, it is almost certain that larvae may be swallowed from time to time. Causey (*26*) experimentally fed larvae to a puppy, and obtained no survival of the larvae. Records of this species in intestinal myasis may be due to misidentification, misinterpretation, or subsequent contamination.

### DROSOPHILA FUNEBRIS (Fabricius)

Recognition Characters.—Adult: The facial carina is prominent; the greatest width of the cheek is about one-fourth that of the eye. The mesonotum and scutellum are reddish brown and unmarked, the pleura likewise unmarked but becoming somewhat paler below. The acrostical hairs are in eight rows. The front basitarsus of the male is simple. Length about 2.5 mm. Larvae (fig. 93, *B*): The larvae of this species are somewhat larger than those of *D. melanogaster*, and measure about 7 mm. in length. The posterior end tapers to the spiracles, which are black; the spinous areas completely encircle the anterior portion of each segment, though they are more pronounced ventrally; the last segment and the bases of the spiracles are covered with fine hairs.

Geographical Distribution.—Nearctic Region: Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Virginia, Georgia, Alabama, Mississippi, Tennessee, Ohio, Michigan, Indiana, Illinois, Kentucky, Minnesota, Wisconsin, Iowa, Missouri, South Dakota, Nebraska, Kansas, Arkansas, Louisiana, Oklahoma, Texas, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona, Washington, Oregon, California. Neotropical Region: Mexico, Costa Rica, Panama, Puerto Rico, Trinidad. Palaearctic Region: England, Spain, France, Netherlands, Italy, Sicily, Norway, Sweden, Finland, Denmark, Germany, Austria, Hungary, Rumania, Azores, Canary Islands, European Russia, Kamchatka, China (Soochow), Japan. Ethiopian Region: Rhodesia, South Africa, Mauritius. Australian Region: Western Australia, New South Wales.

**Biology and Pathogenesis.**—This species will breed on various kinds of fruits, though it is not so often found on fruits as are many other species. It will breed freely in animal matter that has been preserved in formalin and then allowed to dry; it has been reported from formalin vats, fleshy fungi, cesspools, and human excrement. Oviposition begins when the females are about 3 days old; at moderate summer temperatures the eggs will give rise to adults in about 2 weeks.

This species has been recorded as producing intestinal myiasis in a man in Virginia. The breeding habits of the fly and its endurance of so powerful a chemical agent as formalin would make this record seem more plausible than records for *D. melanogaster*. Perhaps records for *D. melanogaster* may really be due to misidentifications of *D. funebris*.

## The Family TYLIDAE

### TREPIDARIA CIBARIA (Linnaeus)

Synonym.—*Calobata cibaria* (Linnaeus).

**Pathogenesis.**—This species has been reported in connection with intestinal myiasis in man, but the record is highly questionable. Little is known of the biology of the flies of this family. Some breed in excrement, including that of man, and it is probable that the record was obtained through the examination of a contaminated stool.

## The Family PIOPHILIDAE

This family includes some rather slender flies, usually 5 mm. or less in length and mainly of a glossy black color. The antenna is short in most species, the third segment being oval, with the arista arising near its base; the eyes are round; the occiput convex and prominent. Vibrissae are present; the postvertical bristles are divergent; the frontoorbitals are rather weak, with not more than two pairs developed. Vein *sc* is complete; the second basal and the discal cells are separated. The legs and abdomen are never strongly bristled. The family is related to the Sepsidae, but may be distinguished by the lack of the small, but evident, postspiracular bristles that characterize that family.

Only one species is of known medical importance.

### The Genus PIOPHILA Fallén

The antennae are short, the first and second segments being shorter in their combined length than the third; the arista is bare. Only one dorsocentral bristle, the prescutellar one, is present. Vein $m_{1+2}$ parallels $r_{4+5}$ beyond the posterior cross vein; the anterior cross vein reaches the discal cell slightly beyond its middle, and anterior to its apical third. The abdomen shows five pregenital segments.

#### PIOPHILA CASEI (Linnaeus)

The Cheese Skipper

RECOGNITION CHARACTERS.—Adult: This is a black fly 2.5–4 mm. in length, with the lower part of the head, the antennae, and parts of the legs yellow. The

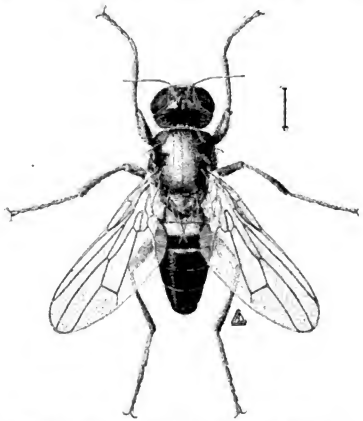

FIGURE 94.—*Piophila casei*, adult female.

ocellar bristles are small, widely distant, and located opposite the front ocellus; the fronto-orbitals are undeveloped. The cheeks are prominent and distinctly more than half the eye height. The mesonotum is scabrous; in the center it

lacks pubescence but bears three rows of setulae; humeral, presutural, and sternopleural bristles are absent. Larva (fig. 95): The larva is slender, cylindrical, and translucent, tapering anteriorly into a cone and truncated posteriorly, with three pairs of protuberances on the last segment, the ventral pair being very prominent. The mature larva measures 6–8 mm. in length and becomes somewhat whiter and more opaque than the preceding stages.

GEOGRAPHICAL DISTRIBUTION.—Almost cosmopolitan. Nearctic Region: Greenland, Alaska, Canada (to the Arctic Zone), Labrador, Quebec, Alberta, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, North Carolina, Georgia, Florida, Alabama, Mississippi, Ohio, Michigan, Minnesota, Wisconsin, Missouri, South Dakota, Kansas, Louisiana, Texas, Montana, Idaho, Colorado, New Mexico, Washington, Oregon, California. Neotropical Region: Mexico, Costa Rica, Bermuda, Jamaica, Colombia, Ecuador, Brazil, Bolivia, Chile, Argentina, Patagonia. Palaearctic Region: Scotland, England, France, Netherlands, Italy, Sardinia, Sicily, Sweden, Germany, Austria, Greece, European Russia (northward to Arkhangelsk), Canary Islands, Madeira, Libia, Egypt, Siberia. Oriental Region: India, Sumatra, Java. Ethiopian Region: Belgian Congo, Uganda. Australian Region: Queensland, New South Wales, New Zealand, Marquesas Islands, Hawaiian Islands.

**Biology and Pathogenesis.**—Both adults and larvae seek the dark. Eggs may be laid on meat such as smoked or cured ham, on cheese,

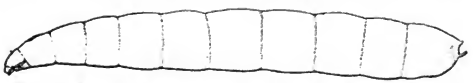

FIGURE 95.—*Piophila casei*, mature larva.

and on other food substances. Eggs sometimes hatch in 1 day in warm weather. Development is rapid, and the life cycle may be completed in as few as 11 to 12 days, although it usually requires from 2 weeks to a month. There are three larval instars; the third-stage larvae develop a habit of leaping, especially when disturbed, which gives the fly its common name. By virtue of their slender shape and pointed anterior end, they can crawl into very small cracks and into the connective tissue between muscle bundles of preserved meat; for this reason they are often found unusually deep in preserved foodstuffs.

A summary of the pathogenic role of this species in human myiasis is given by Simmons (*141*). Experimental evidence has shown that the larvae can pass through the intestine of dogs alive, and that in so doing they produce serious intestinal lesions. Evidently the same is true of man. Numerous cases of intestinal myiasis have been reported; it has even been known to pupate and emerge as an adult, thereby producing intense colic in its host. This is considered the most common of insects found in the human intestine. One case of nasal myiasis, accompanied by a profuse nasal discharge and pain of several weeks' duration, and another in which larvae were "expectorated by a patient suffering from an infection of the chest," have been reported (Austen *5*). Both these reports were substantiated when the larvae were reared to the adult stage.

**Literature.**—Simmons (*141*) gives an extended account of the biology, immature stages, and medical importance of this species.

## The Family SEPSIDAE

These are small, slender, shining black or reddish flies, which look somewhat like ants. The head is spherical; the anterior part of the front lacks bristles; the vibrissae are present, though often weak; palpi

are vestigial. The costa is without fractures on its basal half; the subcosta is distinct. The abdomen is cylindrical, somewhat elongated, usually narrowed at its base. A useful character which will distinguish members of this family from all Acalypteratae other than the very dissimilar Ropalomeridae is the presence on the rim of the posterior spiracle of one or more bristlelike hairs; these are best seen under at least a moderate magnification.

The adults are common around excrement and decaying vegetation; the larvae are scavengers.

### The Genus SEPSIS Fallén

In this genus the front is without bristles, but there are two pairs of verticals; the first and second basal cells are separated; and the

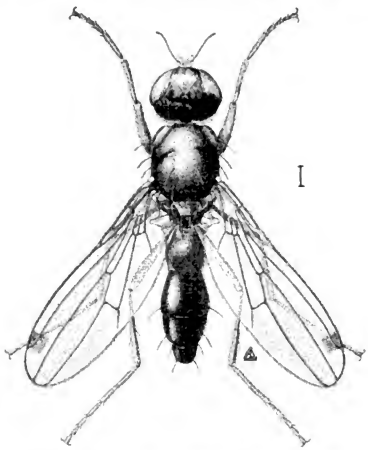

FIGURE 96.—*Sepsis violacea*, adult female.

anterior femora, though they may bear coarse spines, are never provided with a row of close-set spinules ventrally.

**Pathogenesis.**—The larvae breed chiefly in excrement, including that of man; however, they may occur in decaying food.

## The Family PHORIDAE

This family includes a number of small hump-backed flies of a characteristic appearance and, in the winged forms, with a very distinctive venation. The front is wide and usually bears a number of well-developed bristles. The antennae have three segments, the third segment being very large and tending to obscure the small basal two; the arista may be dorsal or apical. The wing venation consists of two

strong longitudinal veins ($r_1$ and $r_5$) $r_5$ sometimes being forked, and four or five weaker ones extending from them to or toward the posterior margin; the strong veins are near the costa and usually do not extend beyond the basal half of the wing.

### The Genus MEGASELIA Rondani

The name *Aphiochaeta* is sometimes used, either in a generic or subgeneric sense, for some members of this genus.

The following characters will apply to most members of this genus, including both of those treated here: The head is of the usual phorid type, with a short proboscis; the epistoma is not produced; there are two pairs of bristles on the anterior part of the front, above the antennae, both of these pairs being proclinate. The wings are well developed and normal, the vein $r_5$ being forked. The posterior tibia bears a row of dense, contiguous hairs on its dorsal surface and a row of short, well spaced bristles on the posterodorsal surface.

**Larva.**—The larva (fig. 98) may be recognized by its small size (the mature larvae of the species treated here being about 4 mm. in length), the broad, somewhat flattened body segments, and the method of progression which resembles that of a geometrid or measuring worm. The puparium is somewhat shorter and more robust than the larva; the anterior spiracles are extended into long rodlike processes, which may be simple or, on the other hand, rather complex in structure.

**Literature.**—Patton (*103*) has described the stages and life histories of the two species known to be involved in myiasis of man and animals.

**Taxonomy.**—The genus is a large one, and exact identifications can be made only by a specialist who has access to the necessary literature and collections. Consequently, no recognition characters that will do more than separate the species treated here can be given in this work.

#### MEGASELIA SCALARIS (Loew)

(Fig. 97)

SYNONYMS.—*Aphiochaeta xanthina* Speiser; *Aphiochaeta ferruginea* Brunetti.

RECOGNITION CHARACTERS.—Adult: The thorax is yellow or yellowish brown, with the halteres and legs clear yellow; the abdomen is yellowish brown, sometimes light but often darker, usually banded with brown, sometimes almost wholly brown in the male. Length, 2–3 mm. Larva: Color, dirty white. The head has a pair of toothed mandibles in place of the usual hooks. Each body segment is provided with short fleshy processes on the dorsal and lateral surfaces; these processes gradually increase in length to the eighth segment, but the longest are shorter than the humps bearing the posterior spiracles; the processes are not hairy.

GEOGRAPHICAL DISTRIBUTION.—Nearctic Region: New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Georgia, Florida, Indiana, South Dakota, Texas. Neotropical Region: Mexico, British Honduras, El Salvador, Honduras, Canal Zone, Bermuda, Bahama Islands, Cuba, Jamaica, Dominican Republic, Puerto Rico, Lesser Antilles (St. Vincent, Grenada, Tobago), Colombia, Galapagos Islands, Brazil, Peru, Argentina. Palaearctic Region: Germany, Canary Islands. Oriental Region: India, Burma, China. Ethiopian Region: Senegal (Dakar), Sierra Leone, Gold Coast, Cameroun, Ethiopia, Belgian Congo, Rodriquez. Australian Region: Guam, Samoa, Fiji, Hawaiian Islands.

**Biology and Pathogenesis.**—Eggs are laid in various media, including fruits, stale meat, excrement, and carrion. The females are attracted to foul-smelling exudations from sores, and oviposition

there may result in wound myiasis. Patton has recorded five cases of wound myiasis in man and animals in which this fly was involved, either alone or in association with *Megaselia rufipes* or *Chrysomya bezziana*. It has also been reared from a sore on the foot of an Indian in British Honduras and from scrapings from the skin of a Colombian negro suffering from caraate. It is possible that many cases of myiasis involving this species may have been overlooked because of the small size of the larvae.

Apparently authentic cases of intestinal myiasis have been attributed to this species. A remarkable case is that of a European in Burma who passed, at intervals of about 2 months for approximately a year, newly hatched larvae, puparia, and at one time 8 to 12 adult flies. The infestation was apparently caused by eating candied bael fruit, but precautions had been taken to prevent reinfestation. Evi-

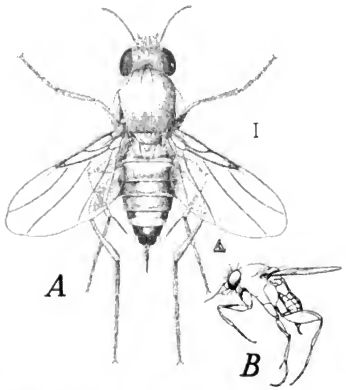


FIGURE 97.—*Megaselia scalaris*, adult female: *A*, Dorsal view; *B*, side view.

dently the flies were maturing and even reproducing within the digestive tract. Patton considers this a possibility on the strength of his breeding experiments in which flies were reared to maturity and induced to mate and reproduce in small, tightly corked vials that were opened only when it was necessary to feed the larvae or remove dead flies.

In one case of ophthalmic myiasis living larvae were recovered from a diseased cornea. Patton believes that such cases may be more frequent than supposed, the small larvae being easily overlooked, and that such infestations might result in severe injury if neglected.

This species has been found repeatedly in human and animal excrement. Fruits and stale meat, but also other contaminated food, including milk, may produce the parasitism.

### MEGASELIA RUFIPES (Meigen)

RECOGNITION CHARACTERS.—Adult: The thorax is dark brown, often with a reddish tinge, appearing black in dried specimens; the legs are light yellow; the

abdomen is dark brown, often appearing black in dried specimens; its ventral surface is light yellow. Larva (fig. 98): Color, yellowish white. The head has the usual hooks. Each body segment is provided with six pairs of hairy, fleshy processes which gradually increase in length toward the posterior segments; the processes at the sides are long, the longest being definitely longer than the humps bearing the posterior spiracles.

Geographical Distribution.—Nearctic Region: Alaska, Labrador, Quebec, Ontario, Alberta, British Columbia, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, Florida, Michigan, Illinois, Kentucky, Minnesota, Idaho, Colorado, New Mexico, Washington, Oregon, California. Neotropical Region: Brazil, Chile, Argentina, Patagonia. Palaearctic Region: Scotland, England, Spain, France, Netherlands, Belgium, Switzerland, Italy, Corsica, Norway, Sweden, Finland, Estonia, Denmark, Austria, Hungary, Yugoslavia, Rumania, European Russia (Arkhangelsk), Canary Islands, Madeira, Tunisia, Libia, Siberia. Oriental Region: India. Ethiopian Region: South Africa (Mossel Bay). Widespread and very common in Europe and North America.

**Pathogenesis.**—Patton has recorded two cases of wound myiasis in cattle in India caused by this species, one of them in association with

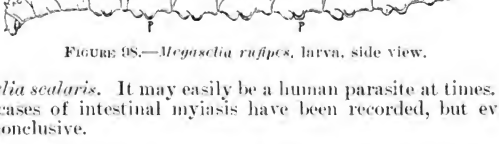


Figure 98.—*Megaselia rufipes*, larva, side view.

*Megaselia scalaris*. It may easily be a human parasite at times. Supposed cases of intestinal myiasis have been recorded, but evidence is not conclusive.

## The Family LARVAEVORIDAE (Tachinidae)

The Tachina Flies

The family Larvaevoridae, in the broad but not the broadest sense—that is, to include the Dexiidae, Prosenidae, etc., but to exclude such families as the Oestridae, Calliphoridae, and Sarcophagidae—may, for practical purposes, be readily distinguished from other calypterate muscoids by having at least moderately well-developed mouth parts, a well-developed postscutellum, vein $m_{1+2}$ strongly bent forward so as to narrow or close the apical cell, and hypopleural bristles present. Some species of comparatively rare occurrence will not conform to the above diagnosis. The family is a large one, with a great many genera and species. The larvae are usually parasitic on other insects. The one record of human myiasis is very surprising.

### The Genus MINTHO Robineau-Desvoidy

#### MINTHO ALGIRA (Macquart)

Synonym.—*Mintho praeceps* var. *algira* (Macquart).

No attempt will be made to give the distinguishing characteristics of the genus or species; determinations in this family should be made by a specialist. In general the fly is black, with considerable silvery pollen on the head and thorax; the abdomen is reddish yellow, with a median black vitta of varying form and width; the legs are yellowish, the tarsi becoming black; the general body form is elongated; length 9–12 mm. Onorato's illustration is sketchy

but may refer to this species; however, the antennal arista is pubescent, rather than plumose, as illustrated.

GEOGRAPHICAL DISTRIBUTION.—Palaearctic Region: Algeria, Libia (Tripolitania). Ethioplan Region: Eritrea.

**Pathogenesis.**—Larvae of *Mintho* parasitize lepidopterous larvae as far as known, the only recorded exception being the unique case of Onorato (*96*). In a patient in Tripolitania two sinuses produced by mycetoma of the left foot were found to contain 13 larvae, those of one of the sinuses living in a deep accessory cavity. Whether the cavity was caused by the mycetoma or the larvae could not be determined. Eight of the larvae, when found, were mature and were reared to the adult stage. The determination was made by Bezzi. As Onorato says, the exact pathogenic role was uncertain and, even if healthy tissue was involved, the occurrence of myiasis is too rare to be of any importance.

## LITERATURE CITED


(1) ALDRICH, J. M.
1916. SARCOPHAGA AND ALLIES IN NORTH AMERICA. Ent. Soc. Amer.—Thomas Say Found. [302] pp., illus. LaFayette, Ind.

(2) ———
1930. NOTES ON THE TYPES OF AMERICAN TWO-WINGED FLIES OF THE GENUS SARCOPHAGA AND A FEW RELATED FORMS, DESCRIBED BY THE EARLY AUTHORS. U. S. Natl. Mus. Proc. 78 (2855): [1]–39, illus.

(3) ANDERSON, W. B.
1935. OPHTHALMOMYIASIS. Amer. Jour. Ophth. 18: 699–705, illus. St. Louis, Mo.

(4) AUBERTIN, D.
1933. REVISION OF THE GENUS LUCILIA R.-D. (DIPTERA, CALLIPHORIDAE). Linn. Soc. London, Jour. Zool. 38: 389–436, illus.

(5) AUSTEN, E. E.
1912. BRITISH FLIES WHICH CAUSE MYIASIS IN MAN. [Gt. Brit.] Local Govt. Bd., Pub. Health and Med. Subjs. (n. s.) 66: 5–15, illus. London.

(6) ———
1926. THE HOUSE-FLY, ITS LIFE-HISTORY, IMPORTANCE AS A DISEASE CARRIER AND PRACTICAL MEASURES FOR ITS SUPPRESSION. Brit. Mus. Nat. Hist. Econ. Ser. 1a, Ed. 2, 68 pp., illus.

(7) ———
1939. THE HOUSE FLY. Brit. Mus. Nat. Hist. Econ. Ser. 1, Ed. 4, rev. by J. Smart, 25 pp., illus. London.

(8) AUSTMANN, K. J.
1926. CREEPING ERUPTION; REPORT OF FIRST CASE FROM MANITOBA. Amer. Med. Assoc. Jour. 87: 1196–1200, illus.

(9) BACIGALUPO, J., VUILLEFOT, C. P., AND DIDEICO, E. P.
1931. UEBER DAS GENUS CUTEREBRA. CLARK (DIPTERA, OESTRIDAE); EINTEILENAX L. Semana Méd. (Buenos Aires) 48 (2486): 555–556, illus.

(10) BAU, A.
1931. UEBER DAS GENUS CUTEREBRA, CLARK (DIPTERA, OESTRIDAE); EINTEILUNG DESSELBEN IN SECHS UNTERGATTUNGEN; BESCHREIBUNG NEUER SPECIES UND AUFSTELLUNG EINER BESTIMMUNGSTABELLE DER MITTEL- UND SÜDAMERIKANISCHEN ARTEN. Konowia 10: 197–240, illus.

(11) BEACHLEY, R. G., AND BISHOPP, F. C.
1942. REPORT OF A CASE OF NASAL MYIASIS DUE TO A BOT FLY LARVA (CUTEREBRA SP.). Va. Med. Monthly 69: 41–42, illus.

(12) BECKER, T.
1926. EPHYDRIDAE. *In* Lindner's Die Fliegen der Palaearktischen Region, Bd. 6, Teil 56. Stuttgart.

(13) Bedford, G. A. H.
1926. check-list of the muscidae and oestridae which cause myiasis in man and animals in south africa. Union So. Africa Dept. Agr. Dir. Vet. Ed. and Res. Rpt. 11 and 12, pt. 1: [483]–491.
(14) Bertram, D. S.
1938. a note upon myiasis due to the larvae of cordylobia rodhaini gedoelst. Ann. Trop. Med. and Parasitol. 32: 431–435, illus.
(15) Bezzi, M.
1927. some sarcophagid flies (diptera) from the south pacific islands. Ann. and Mag. Nat. Hist., Ser. 9, 19: 301–309.
(16) ———
1927. some calliphoridae (diptera) from the south pacific islands and australia. Bul. Ent. Res. 17: 231–247.
(17) ———
1928. diptera brachycera and athericera of the fiji islands. Based on material in the British Museum (Natural History). 220 pp., illus. London.
(18) Bishopp, F. C., Laake, E. W., Brundrett, H. M., and Wells, R. W.
1926. the cattle grubs or ox warbles, their biologies and suggestions for control. U. S. Dept. Agr. Bul. 1369, 120 pp., illus.
(19) Blacklock, B., and Thompson, M. G.
1923. a study of the tumbu-fly, cordylobia anthropophaga grünberg, in sierra leone. Ann. Trop. Med. and Parasitol. 17: 443–502, illus.
(20) Blanchard, R.
1892. sur les oestrides américains dont la larve vit dans la peau de l'homme. Soc. Ent. de France Ann. 61: 109–154, illus.
(21) Bryan, W. J., Jr.
1937. myiasis. Amer. Med. Assoc. Jour. 109: 573–574.
(22) Cameron, A. E.
1932. arthropod parasites of the red deer (cervus elaphus l.) in scotland. Roy. Phys. Soc. Edinb., Proc. 22: 81–89.
(23) ———
1937. insects and other pests of 1936. parasites of the red deer (cervus elaphus). Highland and Agr. Soc. Scot. Trans., Ser. 5, 49: 130–147, illus.
(24) Carter, H. F., and Blacklock, B.
1913. external myiasis in a monkey. Brit. Med. Jour. No. 2715: 72.
(25) Castellani, A., Sir, and Chalmers, A. J.
1919. manual of tropical medicine. Ed. 3. 2436 pp., illus. London.
(26) Causey, O. R.
1938. experimental intestinal myiasis. Amer. Jour. Hyg. 28: 481–486.
(27) Chevrel, R.
1909. sur la myase des voies urinaires. Arch. de Parasitol. 12: [369]–450, illus.
(28) Curran, C. H.
1930. new species of eristalinae with notes (syrphidae, diptera). Amer. Mus. Nat. Hist. Amer. Mus. Novitates 411, 27 pp.
(28a) ———
1934. sarcophaginae of the american museum congo expedition. (diptera). Amer. Mus. Nat. Hist. Amer. Mus. Novitates 727, 31 pp., illus.
(29) ———
1934. the families and genera of north american diptera. 512 pp., illus. New York.
(30) ———
1934. the diptera of kartabo, bartica district, british guiana, with descriptions of new species from other british guiana localities. Amer. Mus. Nat. Hist. Bul. 66: 287–532, illus.
(31) Cuthbertson, A.
1933. the habits and life histories of some diptera in southern rhodesia. Rhodesia Sci. Assoc. Proc. 32: 81–111, illus.
(32) ———
1934. the life history of the screw-worm fly. [*Chrysomyia bezziana* Villen. in Southern Rhodesia.] Rhodesia Agri. Jour. 31: 256–258, illus. (Rhodesia Agr. Dept. Bul. 917, 4 pp., illus.)

(33) DINULESCU, G.
1932. RECHERCHES SUR LA BIOLOGIE DES GASTROPHILES ANATOMIE, PHYSIOLOGIE, CYCLE ÉVOLUTIF. Ann. des Sci. Nat., Zool., Ser. 10, 15: 1–183, illus.

(34) DOVE, W. E.
1937. MYIASIS OF MAN. Jour. Econ. Ent. 30: 29–39.

(35) DUNN, L. H.
1930. REARING THE LARVAE OF DERMATOBIA HOMINIS LINN. IN MAN. Psyche 37: 327–342, illus.

(36) ———
1934. PREVALENCE AND IMPORTANCE OF THE TROPICAL WARBLE FLY, DERMATOBIA HOMINIS LINN., IN PANAMA. Jour. Parasitol. 20: [219]–226.

(37) DUPUY D'URY, P.
1931. A PROPOS D'UN NOUVEAU CAS DE MYIASE OCULAIRE Á OESTRUS OVIS OBSERVÉ À ALGER. Inst. Pasteur d'Algérie, Arch. 9: 630–637, illus.

(38) EDWARDS, F. W.
1928. DIPTERA, FAM. PROTORHYPHIDAE, ANISOPODIDAE, PACHYNEURIDAE, TRICHOCERIDAE. *In* Wytsman, Genera Insectorum, fasc. 190.

(39) FELT, E. P.
1928. OBSERVATIONS AND NOTES ON INJURIOUS AND OTHER INSECTS OF NEW YORK STATE. N. Y. State Mus. Bul. 274: [145]–176, illus.

(40) FORD, N.
1936. FURTHER OBSERVATIONS ON THE BEHAVIOUR OF WOHLFAHRTIA VIGIL (WALK.) WITH NOTES ON THE COLLECTING AND REARING OF THE FILES. Jour. Parasitol. 22: [309]–328, illus.

(41) FULLER, M. E.
1932. THE LARVAE OF THE AUSTRALIAN SHEEP BLOWFLIES. Linn. Soc. N. S. Wales, Proc. 57: 77–91, illus.

(42) GALLIARD, H.
1934. UN NOUVEAU CAS DE MYIASE OCULAIRE DUE À OESTRUS OVIS EN FRANCE. Ann. de Parasitol. Humaine et Compar. 12: [177]–181, illus.

(43) GALLI-VALERIO, B.
1929. SUR QUELQUES CAS DE MYIASES OBSERVÉS CHEZ L'HOMME. Schweiz. Med. Wchnschr. 69: 451–452.

(44) GALTSOFF, P. S., LUTZ, F. E., WELCH, P. S., AND OTHERS.
1937. CULTURE METHODS FOR INVERTEBRATE ANIMALS. 590 pp., illus. Ithaca, N. Y.

(45) GREENE, C. T.
1925. THE PUPARIA AND LARVAE OF SARCOPHAGID FLIES. U. S. Natl. Mus. Proc. 66: 1–26, illus.

(46) HAFEZ, M.
1940. A STUDY OF THE MORPHOLOGY AND LIFE HISTORY OF SARCOPHAGA FALCULATA PANDELLÉ [DIPTERA: SARCOPHAGIDAE]. [Egypt] Soc. Fouad 1er Ent. Bul. 24: 183–212, illus.

(47) HALL, D. G.
1933. THE SARCOPHAGINAE OF PANAMA (DIPTERA, CALLIPHORIDAE). Amer. Mus. Nat. Hist. Bul. 66: 251–285, illus.

(48) ———
1937. SARCOPHAGINAE. Brit. Mus. Nat. Hist. Diptera of Patagonia and South Chile. Part 7, fasc. 3—Calliphoridae, pp. [347]–375, illus.

(49) ———
1948. THE BLOWFLIES OF NORTH AMERICA. Ent. Soc. Amer.—Thomas Say Found. [Pub.] 4, 477 p., illus. Baltimore, Md.

(50) HALL, M. C.
1918. A NOTE REGARDING MYIASIS, ESPECIALLY THAT DUE TO SYRPHID LARVAE. Arch. Int. Med. 21: 309–312.

(51) ——— AND MUIR, J. T.
1913. A CRITICAL STUDY OF A CASE OF MYIASIS DUE TO ERISTALIS. Arch. Int. Med. 11: 193–203.

(52) HARDY, G. H.
1936. NOTES ON SARCOPHAGINAE IN INDIA AND AUSTRALIA. Linn. Soc. N. S. Wales, Proc. 61: [89]–97.

(53) ———
1936. NOTES ON AUSTRALIAN MUSCOIDEA II. SUBFAMILY MUSCINAE. Roy. Soc. Queensland, Proc. 48: 22–29.

(54) ———
1937. NOTES ON GENUS CALLIPHORA (DIPTERA). Linn. Soc. N. S. Wales, Proc. 62: 17–26, illus.

(55) HARRELL, W. B., AND MOSELEY, V.
1942. SURGICAL TREATMENT OF SUBDERMAL MYIASIS DUE TO DERMATOBIA HOMINIS. South. Med. Jour. 35: 720–723, illus.
(56) HASEMAN, L.
1917. SARCOPHAGA HAEMORRHOIDALIS LARVAE AS PARASITES OF THE HUMAN INTESTINE (DIPT.). Ent. News 28: 343–346.
(57) HERMS, W. B., AND GILBERT, Q. O.
1933. AN OBSTINATE CASE OF INTESTINAL MYIASIS. Ann. Internal Med. 6: 941–945.
(58) HEWITT, C. G.
1912. FANNIA (HOMALOMYIA) CANICULARIS LINN. AND F. SCALARIS FAB. AN ACCOUNT OF THE BIONOMICS AND THE LARVAE OF THE FLIES AND THEIR RELATION TO MYIASIS OF THE INTESTINAL AND URINARY TRACTS. Parasitology 5: [161]–174, illus.
(59) HOLDAWAY, F. G.
1933. THE SYNONYMY AND DISTRIBUTION OF CHRYSOMYIA RUFIFACIES (MACQ.), AN AUSTRALIAN SHEEP BLOWFLY. Bul. Ent. Res. 24: 549–560, illus.
(60) HOPE, F. W.
1840. ON INSECTS AND THEIR LARVAE OCCASIONALLY FOUND IN THE HUMAN BODY. Roy. Ent. Soc., London, Trans. 2: 256–271.
(61) JOHANNSEN, O. A.
1934. AQUATIC DIPTERA. PART I. NEMOCERA, EXCLUSIVE OF CHIRONOMIDAE AND CERATOPOGONIDAE. N. Y. (Cornell) Agr. Expt. Sta. Mem. 164, 71 pp., illus.
(62) ———
1935. AQUATIC DIPTERA. PART II. ORTHORRHAPHA-BRACHYCERA AND CYCLORRHAPHA. N. Y. (Cornell) Agr. Expt. Sta. Mem. 177, 62 pp., illus.
(63) KARL, O.
1928. ZWEIFLÜGLER ODER DIPTERA. III: MUSCIDAE. *In* Die Tierwelt Deutschlands . . . Teil 13. Jena.
(64) KEIFER, H. H.
1930. SYNOPSIS OF THE DIPTEROUS LARVAE FOUND IN CALIFORNIA FRUIT. Calif. Dept. Agr., Monthly Bul. 19: 574–581, illus.
(65) KEILIN, D.
1915. RECHERCHES SUR LES LARVES DE DIPTÈRES CYCLORHAPES. Bul. Biol. de la France et Belg., Ser. 7, 49: [15]–198, illus.
(66) ———
1917. RECHERCHES SUR LES ANTHOMYIDES À LARVES CARNIVORES. Parasitology 9: [326]–450, illus.
(67) ———
1924. ON THE LIFE HISTORY OF ANTHOMYIA PROCELLARIS ROND. AND A. PLUVIALIS L. INHABITING THE NESTS OF BIRDS. Parasitology 16: 150–159, illus.
(68) ——— AND TATE, P.
1940. THE EARLY STAGES OF THE FAMILIES TRICHOCERIDAE AND ANISOPODIDAE (=RHYPHIDAE) (DIPTERA: NEMATOCERA). Roy. Ent. Soc., London, Trans. 90: 39–62, illus.
(69) KINGSCOT[T]E, A. A.
1935. MYIASIS IN MAN AND ANIMALS DUE TO INFECTION WITH THE LARVAE OF WOHLFAHRTIA VIGIL (WALKER). Ontario Vet. Col. Rpt. (1934), 51–69, illus.
(70) KIRBY, W., AND SPENCE, W.
1818. AN INTRODUCTION TO ENTOMOLOGY. Vol. 1, Ed. 3, 519 pp., illus. London.
(71) KIRBY-SMITH, J. L., DOVE, W. E., AND WHITE, G. F.
1926. CREEPING ERUPTION. Arch. Dermat. and Syph. 13: 137–173, illus.
(72) KNIPLING, E. F.
1935. THE LARVAL STAGES OF HYPODERMA LINEATUM DEVILLERS AND HYPODERMA BOVIS DEGEER. Jour. Parasitol. 21: [70]–82.
(73) ———
1936. A COMPARATIVE STUDY OF THE FIRST-INSTAR LARVAE OF THE GENUS SARCOPHAGA (CALLIPHORIDAE, DIPTERA), WITH NOTES ON THE BIOLOGY. Jour. Parasitol. 22: [417]–454, illus.
(74) ———
1939. A KEY FOR BLOWFLY LARVAE CONCERNED IN WOUND AND CUTANEOUS MYIASIS. Amer. Ent. Soc. Ann. 32: 376–383, illus.

(75) KNIPLING, E. F., AND RAINWATER, E. T.
1937. SPECIES AND INCIDENCE OF DIPTEROUS LARVAE CONCERNED IN WOUND MYIASIS. Jour. Parasitol. 23: [151]–155.
(76) KOMÁREK, J.
1936. SUR LE PROBLÈME DE LA MYASE INTESTINALE. Brussels Mus. Roy. d' Hist. Nat. Mém. Ser. 2, fasc. 3: [23]–30.
(77) LAAKE, E. W., CUSHING, E. C., AND PARISH, H. E.
1936. BIOLOGY OF THE PRIMARY SCREW WORM FLY, COCHLIOMYIA AMERICANA, AND A COMPARISON OF ITS STAGES WITH THOSE OF C. MACELLARIA. U. S. Dept. Agr. Tech. Bul. 500, 24 pp., illus.
(78) LABOULBÈNE, A.
1867. HISTOIRE DES MÉTAMORPHOSES DE LA TEICHOMYZA FUSCA. Soc. Ent. de France Ann., Ser. 4, 7: [33]–42, illus.
(79) LAMPA, S.
1887. OM FLUGLARVERS FÖREKOMST I TARMKANALEN HOS MENNISKAN (SUR LA PRÉSENCE DE LARVES DE MOUCHES DANS LE CANAL INTESTINAL DE L'HOMME). Ent. Tidskr. 8: 5–20 [In Swedish. French résumé pp. 136–153.]
(80) LARROUSSE, F.
1921. LA MYIASE OCULAIRE À OESTRUS OVIS L. DANS LA RÉGION PARISIENNE. Soc. de Path. Exot. Bul. 14: 595–601, illus.
(81) LEON, N.
1921. A CASE OF URETHRAL MYIASIS. Jour. Parasitol. 7: [184]–185.
(82) LESNE, P.
1921. LA FAUNE ENTOMOLOGIQUE DES FOSSES D'AISANCES DE LA RÉGION PARISIENNE. LES FANNIA SCATOPHAGES. Paris Mus. d'Hist. Nat. Bul. 27: 53–59.
(83) LEWIS, E. A.
1933. OBSERVATIONS ON SOME DIPTERA AND MYIASIS IN KENYA COLONY. Bul. Ent. Res. 24: 265–269.
(84) LOPES, H. DE S.
1941. HAWAIIAN SARCOPHAGIDAE. Hawaii. Ent. Soc. Proc. (1940) 11: 53–56.
(85) MALLOCH, J. R.
1917. A PRELIMINARY CLASSIFICATION OF DIPTERA, EXCLUSIVE OF PUPIPARA, BASED UPON LARVAL AND PUPAL CHARACTERS. Ill. Nat. Hist. Survey Bul. 12: [161]–409, illus.
(86) ———
1924. EXOTIC MUSCARIDAE (DIPTERA).—XII, XIV. Ann. and Mag. Nat. Hist., Ser. 9, 13: 409–424; 14: [513]–522, illus.
(87) MAZZA, S., JÖRG, M. E., BASSO, R., AND OTHERS.
1939. INVESTIGACIONES SOBRE DIPTEROS ARGENTINOS. I.—MIASIS. Buenos Aires Univ. Nac. Misión de Estud. de Patol. Region, Pub. 41: [3]–86, illus.
(88) MELLOR, J. E. M.
1919. OBSERVATIONS ON THE HABITS OF CERTAIN FLIES, ESPECIALLY OF THOSE BREEDING IN MANURE. Ann. Appl. Biol. 6: 53–88, illus.
(89) METCALF, C. L.
1916. SYRPHIDAE OF MAINE. Maine Agr. Expt. Sta. Bul. 253: [193]–264, illus.
(90) MILLER, D.
1939. FLOW-FLIES (CALLIPHORIDAE) AND THEIR ASSOCIATES IN NEW ZEALAND. Cawthron Inst. Sci. Res., Monog. 2, 68 pp., illus. Nelson, New Zealand.
(91) MUMFORD, E. P.
1926. THREE NEW CASES OF MYIASIS IN MAN IN THE NORTH OF ENGLAND. Parasitology 18: 375–383.
(92) NATVIG, L. R.
1937. ÜBER DIE DIFFERENTIALDIAGNOSE DER LARVEN VON HYPODERMA BOVIS UND H. LINEATUM. *In* Hamburg, Inst. f. Schiffs-u. Tropenkrank. Festschr. B. Nocht, pp. [386]–393, illus.
(93) NEIVA, A., AND DE FARIA, G.
1913. NOTAS SOBRE UM CASO DE MIIASE HUMANA OCASIONADA POR LARVAS DE SARCOPHAGA PYOPHILA N. SP. Inst. Oswaldo Cruz Mem. 5: [16]–23.
(94) NEWSTEAD, R., AND POTTS, W. H.
1925. SOME CHARACTERISTICS OF THE FIRST STAGE LARVA OF DERMATOBIA HOMINIS GMELIN. Ann. Trop. Med. and Parasitol. 19: 247–260, illus.

(95) O'Brien, C. S., and Allen, J. H.
1939. OPHTHALMOMYIASIS INTERNA ANTERIOR. Amer. Jour. Ophth. 22: 996–998, illus.
(96) Onorato, R.
1922. LE MIASI IN TRIPOLITANIA. Arch. Ital. di Sci. Med. Colon. 3: 14–29, [33]–45, [69]–88, [101]–117, [155]–162, [188]–193, [216]–227, [229]–259, [261]–283, [293]–315, illus.
(97) Paramonov, S. J.
1940. [FLIES OF THE GENUS GASTEROPHILUS AND THEIR CONTROL.] Kiev. Acad. des Sci., Zool. [128]pp., illus. [In Ukrainian.]
(98) Patterson, J. T.
1943. STUDIES IN THE GENETICS OF DROSOPHILA. III—THE DROSOPHILIDAE OF THE SOUTHWEST. Tex. Univ. Pub. 4313, 327 pp., illus.
(99) Patton, W. S.
1920. SOME NOTES ON INDIAN CALLIPHORINAE. PART I—CHRYSOMYIA BEZZIANA VILLENEUVE, THE COMMON INDIAN CALLIPHORINAE WHOSE LARVAE CAUSE CUTANEOUS MYIASIS IN MAN AND ANIMALS. Indian Jour. Med. Res. 8: 17–29, illus.
(100) ———
1921. NOTES ON THE MYIASIS-PRODUCING DIPTERA OF MAN AND ANIMALS. Bul. Ent. Res. 12: 239–261, illus.
(101) ———
1922. SOME NOTES ON INDIAN CALLIPHORINAE. VI—HOW TO RECOGNIZE THE INDIAN MYIASIS-PRODUCING FLIES AND THEIR LARVAE, TOGETHER WITH SOME NOTES ON HOW TO BREED THEM AND STUDY THEIR HABITS. Indian Jour. Med. Res. 9: 635–653, illus.
(102) ———
1922. SOME NOTES ON INDIAN CALLIPHORINAE. VII—ADDITIONAL CASES OF MYIASIS CAUSED BY THE LARVAE OF CHRYSOMYIA BEZZIANA VILL., TOGETHER WITH SOME NOTES ON THE DIPTERA WHICH CAUSE MYIASIS IN MAN AND ANIMALS. Indian Jour. Med. Res. 9: 654–682.
(103) ———
1922. NOTES ON SOME INDIAN APHIOCHAETAE . . . WHOSE LARVAE CAUSE CUTANEOUS AND INTESTINAL MYIASIS IN MAN AND ANIMALS . . . Indian Jour. Med. Res. 9: 683–691, illus.
(104) ———
1932. . . . A REVISION OF THE SPECIES OF THE GENUS MUSCA . . . I.—THE NATURAL GROUPING OF THE SPECIES AND THEIR RELATIONSHIP TO EACH OTHER. Ann. Trop. Med. and Parasitol. 26: 347–405, illus.
(105) ———
1933. . . . A REVISION OF THE SPECIES OF THE GENUS MUSCA . . . II.—A PRACTICAL GUIDE TO THE PALAEARCTIC SPECIES. Ann. Trop. Med. and Parasitol. 27: 327–345, 397–430, illus.
(106) ———
1935. THE GENERA ADICHOSIA SURCOUF AND AUCHMEROMYIA BRAUER AND VON BERGENSTAMM (SENS. LAT). Ann. Trop. Med. and Parasitol. 29: 199–230, illus.
(107) ———
1936. THE WARBLE FLIES OF THE GENUS HYPODERMA. Ann. Trop. Med. and Parasitol. 30: 453–468, illus.
(108) ———
1936. . . . A REVISION OF THE SPECIES OF THE GENUS MUSCA . . . III.—A PRACTICAL GUIDE TO THE ETHIOPIAN SPECIES (CON.). Ann. Trop. Med. and Parasitol. 30: 469–490, illus.
(109) ———
1937. . . . A REVISION OF THE SPECIES OF THE GENUS MUSCA . . . IV.—A PRACTICAL GUIDE TO THE ORIENTAL SPECIES. Ann. Trop. Med. and Parasitol. 31: 127–140, 195–213, illus.
(110) ——— and Wainwright, C. J.
1935–37. THE BRITISH SPECIES OF THE SUBFAMILY SARCOPHAGINAE, WITH ILLUSTRATIONS OF THE MALE AND FEMALE TERMINALIA. Ann. Trop. Med. and Parasitol. 29: 73–90, 517–532; 30: 187–201, 337–350; 31: 303–317, illus.
(111) Patton, W. S., and Evans, A. M.
1929. INSECTS, TICKS, MITES AND VENOMOUS ANIMALS OF MEDICAL AND VETERINARY IMPORTANCE. PART I.—MEDICAL. 786 pp., illus. Croydon, Eng.

(112) PAVLOVSKY, E. N., and STEIN, A. K.
1924. DIE GASTROPHILUS-LARVE ALS GASTPARASIT IN DER MENSCHENHAUT Parasitology 16: 32–43, illus.
(113) PLESKE, T.
1926. REVUE DES ESPÈCES PALÉARCTIQUES DES OESTRIDAE ET CATALOGUE RAISONNÉ DE LEUR COLLECTION AU MUSÉE ZOOLOGIQUE DE L'ACADÉMIE DES SCIENCES. Leningrad Akad. Nauk Ann. (1925) 26: 215–230.
(114) PORTCHINSKY, I. A.
1906. LE TAON RUSSE (RHINOESTRUS PURPUREUS BR.), PARASITE DU CHEVAL, LARVES ÉJACULÉES DANS LES YEUX DES GENS. Trav. Bur. Ent. Com. Sci. Min. Agr. St. Pétersbourg 6: 1–44, illus. [In Russian.]
(115) ———
1913. MUSCINA STABULANS FALL., MOUCHE NUISIBLE À L'HOMME ET À SON MÉNAGE, EN ETAT LARVAIRE DESTRUCTEUSE DES LARVES DE MUSCA DOMESTICA. [THE DOMESTIC FLY (MUSCINA STABULANS FALL.): ITS IMPORTANCE TO MAN AND HIS HOUSEHOLD, AND ITS RELATIONS WITH THE HOUSEFLY (MUSCA DOMESTICA).] Bur. Ent. Sci. Com. Cent. Bd. Land Admin. Agr. Mem. 10 (1): 39 pp., illus. St. Petersburg. [In Russian. Abstract in Rev. Appl. Ent., Ser. B, 1: 108–110. 1913.]
(116) ———
1913. OESTRUS OVIS, SA BIOLOGIE ET SON RAPPORT À L'HOMME. [OESTRUS OVIS L.; ITS LIFE-HISTORY AND HABITS, THE METHODS OF COMBATING IT AND ITS RELATION TO HUMAN BEINGS.] Bur. Ent. Sci. Com. Cent. Bd. Land Admin. Agr. Mem. 10 (3): 63 pp., illus. St. Petersburg. [In Russian. Abstract in Rev. Appl. Ent., Ser. B, 1: 134–137. 1913.]
(117) ———
1915. [RHINOESTRUS PURPUREUS BR., A PARASITE OF THE HORSE, INJECTING ITS LARVAE INTO THE EYES OF MEN.] Bur. Ent. Sci. Com. Cent. Bd. Land Admin. Agr. Mem. 6 (6): 42 pp., illus. Ed. 3, enl. Petrograd. [In Russian. Abstract in Rev. Appl. Ent., Ser. B, 3: 217–218. 1915.]
(118) ———
1916. WOHLFAHRTIA MAGNIFICA SCHIN. SA BIOLOGIE ET SON RAPPORT À L'HOMME ET AUX ANIMAUX DOMESTIQUES. [WOHLFAHRTIA MAGNIFICA SCHIN., AND ALLIED RUSSIAN SPECIES. THE BIOLOGY OF THIS FLY AND ITS IMPORTANCE TO MAN AND DOMESTIC ANIMALS.] Bur. Ent. Sci. Com. Min. Agr. Mem. 11 (9). 108 pp., illus. Petrograd. [In Russian. Abstract in Rev. Appl. Ent., Ser. B, 4: 88–89. 1916.]
(119) PORTER, A.
1924. NOTES ON SOME INSECT LARVAE THAT MAY OCCUR IN MAN IN SOUTH AFRICA. So. African Jour. Sci. 21: 373–377, illus.
(120) RILEY, W. A.
1930. THE POSSIBILITY OF INTESTINAL MYIASIS IN MAN. Jour. Econ. Ent. 32: 875–876.
(121) ROBERTS, R. A.
1933. ADDITIONAL NOTES ON MYIASIS IN RABBITS (DIPT.: CALLIPHORIDAE, SARCOPHAGIDAE). Ent. News 44: 157–159.
(122) RODHAIN, J., AND BEQUAERT, J.
1916. MATERIAUX POUR UNE ÉTUDE MONOGRAPHIQUE DES DIPTERES PARASITES DE L'AFRIQUE. I.—HISTOIRE DE "PASSEROMYIA HETEROCHAETA" VILLEN., ET DE "STASISIA (CORDYLOBIA) RODHAINI," GED. Bul. Biol. de la France et Belg., Ser. 7, 49: [236]–289, illus.
(123) ———
1916. . . . II.—REVISION DES OESTRINAE DU CONTINENT AFRICAIN. Bul. Biol. de la France et Belg., Ser. 7, 50: [53]–165, illus.
(124) ROHDENDORF, B. B.
1937. SARCOPHAGIDAE. Akad. Nauk S. S. S. R. Inst. Zool. FAUNE DE L'URSS. INSECTES DIPTERES. (n. s. 12) 19 (1), 500 pp., illus. [In Russian. German résumé, pp. [393]–496.]
(125) ROSARIO, F. DEL
1936. THE AMERICAN SPECIES OF PSYCHODA (DIPTERA: PSYCHODIDAE). Philippine Jour. Sci. 59: 85–148, illus.

(126) ROUBAUD, E.
1914. LES PRODUCTEURS DE MYIASES ET AGENTS SIMILAIRES CHEZ L'HOMME ET LES ANIMAUX. *In* Bouet, G. et Roubaud, E. . . . Études sur la Faune Parasitaire de l'Afrique Occidentale Française. Fasc. 1. Paris.

(127) SALEM, H. H.
1935. MYIASIS IN EGYPT. Egypt. Med. Assoc. Jour. 18: 238–254.

(128) ———
1936. A SUMMARY OF THE EGYPTIAN SPECIES OF THE GENUS SARCOPHAGA, WITH A DESCRIPTION OF S. ROHDENDORFI NOV. SPEC. Soc. Roy. Ent. d'Egypte, Bul. 29: 229–247, illus.

(129) ———
1938. A COMPLETE REVISION OF THE SPECIES OF THE GENUS WOHLFAHRTIA B. AND B. Egypt. Univ., Faculty Med., Pub. 13, 90 pp., illus. Cairo.

(130) SAMBON, L. W.
1915. OBSERVATIONS ON THE LIFE-HISTORY OF DERMATOBIA HOMINIS (LINNAEUS JUN., 1781). [Gt. Britain] Trop. Dis. Res. Fund Advisory Com. Rpt. 1914: 119–150, illus.

(131) SCHINER, J. R.
1862. FAUNA AUSTRIACA. DIE FLIEGEN (DIPTERA). 674 pp., illus. Wien, Austria.

(132) SCHMID, F.
1939. BEITRAG ZUR BIOLOGIE DER DASSELFLIEGEN. (HYPODERMA BOVIS UND H. LINEATUM.) Ztschr. f. Infektionskrank., Parasitäre Krank. u. Hyg. der Haustiere 55: [217]–243, illus.

(133) SÉGUY, E.
1923. DIPTÈRES ANTHOMYIDES. Fed. Franc. des Sci. Nat. Faune de France. Vol. 6, 393 pp., illus. Paris.

(134) ———
1923. ETUDE SUR LE MUSCINA STABULANS FALLEN (DIPTÈRE). Paris Mus. d'Hist. Nat. Bul. 29: 310–317, illus.

(134a) ———
1923. NOTE SUR LES LARVES DES MUSCINA STABULANS ET ASSIMILIS (DIPTÈRES). Paris Mus. d'Hist. Nat. Bul. 29: 443–445, illus.

(135) ———
1928. ÉTUDES SUR LES MOUCHES PARASITES. I. CONOPIDES, OESTRIDES, ET CALLIPHORINES DE L'EUROPE OCCIDENTALE. *His* Encyclopédie Entomologique, Sér. A, t. 9, illus.

(136) ———
1935. ÉTUDE SUR LES STOMOXYDINES ET PARTICULIÈREMENT DES MOUCHES CHARBONNEUSES DU GENRE STOMOXYS. *His* Encyclopédie Entomologique, Sér. B, 2, Diptera, t. 8, pp. [15]–58, illus.

(137) ———
1937. DIPTERA, FAMILY MUSCIDAE. *In* Wytsman, Genera Insectorum, fasc. 205, 604 pp., illus.

(138) ———
1938. SUR LES CARACTÈRES COMMUNS AUX MUSCIDES ET AUX OESTRIDES GASTRICOLES. *His* Encyclopédie Entomologique, Sér. B, 2, Diptera, t. 9: [1]–21.

(139) SENIOR-WHITE, R., AUBERTIN, D., AND SMART, J.
1940. THE FAUNA OF BRITISH INDIA, INCLUDING THE REMAINDER OF THE ORIENTAL REGION. DIPTERA, VI. FAMILY CALLIPHORIDAE. 288 pp., illus. London.

(140) SIDDONS, L. B., AND ROY, D. N.
1942. ON THE LIFE HISTORY OF SYNTHESIOMYIA NUDISETA VAN DER WULP (DIPTERA, MUSCIDAE), A MYIASIS-PRODUCING FLY. Parasitology 34: [239]–245, illus.

(141) SIMMONS, P.
1927. THE CHEESE SKIPPER AS A PEST IN CURED MEATS. U. S. Dept. Agr. Bul. 1453, 56 pp., illus.

(142) SINTON, J. A.
1921. SOME CASES OF MYIASIS IN INDIA AND PERSIA, WITH A DESCRIPTION OF THE LARVAE CAUSING THE LESIONS. Indian Jour. Med. Res. 9: [132]–162, illus.

(143) SMIT, B.
1931. A STUDY OF THE SHEEP BLOW-FLIES OF SOUTH AFRICA. Onderstepoort Jour. Vet. Sci. and Anim. Indus. 17: 209–421, illus.
(144) SMITH, C. N.
1933. NOTES ON THE LIFE HISTORY AND MOULTING PROCESS OF SARCOPHAGA SECURIFERA VILLENEUVE. Wash. Ent. Soc. Proc. 35: 159–164, illus.
(145) STEWART, M. A.
1929. A CASE OF DERMAL MYIASIS CAUSED BY PHORMIA REGINA MEIG. Amer. Med. Assoc. Jour. 92: 798–799.
(146) STRICKLAND, C., and ROY, D. N.
1940. EXPERIMENTAL INTESTINAL MYIASIS. Indian Jour. Med. Res. 28: 593–594.
(147) STURTEVANT, A. H.
1921. THE NORTH AMERICAN SPECIES OF DROSOPHILA. Carnegie Inst. Wash., Pub. 301, 150 pp., illus.
(148) TILLYARD, R. J., and SEDDON, H. R. ed.
1933. THE SHEEP BLOWFLY PROBLEM IN AUSTRALIA, REPORT NO. I. Austral. Council Sci. & Indus. Res., Pam. 37 (N. S. Wales Dept. Agr. Sci. Bul. 40), 136 pp., illus.
(149) THOMPSON, W.
1889. LARVAE OF CEPHENOMYIA IN A MARE'S HEAD. Insect Life 2: 116.
(150) TONNOIR, A. L.
1922. SYNOPSIS DE ESPÈCES EUROPÉNNES DU GENRE PSYCHODA (DIPTÈRES). Soc. Ent. de Belg. Ann. 62: [49]–88, illus.
(151) ———
1922. SYNOPSIS DE ESPÈCES EUROPÉNNES DU GENRE PSYCHODA (DIPTÈRES). OF NEW SPECIES. Soc. Brit. Ent. Trans. 7: [21]–64, illus.
(152) TOOMEY, N.
1922. HYPODERMIASIS (OX-WARBLE DISEASE). Brit. Jour. Dermat. and Syph. 34: 31–42, illus.
(153) TOWNSEND, C. H. T.
1934–42. MANUAL OF MYIOLOGY. 12 parts. Sao Paulo, Brazil.
(154) VAN EMDEN, F.
1939. MUSCIDAE: MUSCINAE AND STOMOXYDINAE. Brit. Mus. Nat. Hist., Ruwenzori Expedition, 1934–35, 2: [49]–89, illus.
(155) VIVAS-BETTHIER, G.
1941. EL GUSANO DE MONTE, DE ZANCUDO, O DE MOSQUITO. Rev. de Med. Vet. y Parasitol. [Caracas] 3: [129]–152, illus.
(156) VOGLER, C. H.
1900. BEITRÄGE ZUR METAMORPHOSE DER TEICHMOYZA FUSCA. Ztschr. f. Wiss. Insektenbiol. 5: 1–4, 17–20, 33–36, illus.
(157) WALKER, E. M.
1931. CUTANEOUS MYIASIS IN CANADA. Canad. Pub. Health Jour. 22: [504]–508, illus.
(158) ———
1937. THE LARVAL STAGES OF WOHLFAHRTIA VIGIL WALKER. Jour. Parasitol. 23: [163]–174, illus.
(159) WELLS, R. W., and KNIPLING, E. F.
1938. A REPORT ON SOME RECENT STUDIES ON SPECIES OF GASTEROPHILUS OCCURRING IN HORSES IN THE UNITED STATES. Iowa State Col. Jour. Sci. 12: [181]–203, illus.
(160) ZUMPT, F.
1939. WAS WISSEN WIR ÜBER DIE HYGIENISCHE BEDEUTUNG DER STOMOXYDINAE? Ztschr. f. Hyg. u. Infektionskrank. 121: [679]–731, illus.

# INDEX

(Valid names are in roman type, synonyms in italics.)